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HYDROBIOLOGIA publishes original articles in the field of Hydrobiology, Limnology and Protistology. It will include investigations in the field of marine and freshwater Zoo- and Phytobiology, embracing also research on the Systematics and Taxonomy of the groups covered. Preliminary notices, polemics, and articles published elsewhere will not be accepted. The journal, however, contains short reviews of recent books and papers.

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# Indonesian Desmids

by

ARTHUR M. SCOTT* and GERALD W. PRESCOTT**

SUMMARY:

There are described 526 desmid taxa found in 49 freshwater algal collections from Kalimantan (Borneo), Java, Bali and Sumatra, including 152 new taxa in the genera *Closterium*, *Pleurotaenium*, *Euastrum*, *Micrasterias*, *Cosmarium*, *Arthrodesmus*, *Xanthidium*, *Staurastrum*, *Onychonema*, *Bambusina*, and *Desmidium*.

During the years from 1951 to 1957, Mr. M. SACHLAN, of the Laboratory for Inland Fisheries at Bogor, Java, sent us at various times collections of freshwater algal material from the larger islands of the Indonesian Archipelago, Sumatra, Java, Bali and Kalimantan (Borneo). Most of the material was specially collected by SACHLAN; a few of the earlier samples were gathered by other collectors whose names are given in our listing of the habitats. To Mr. SACHLAN we wish to express our gratitude for affording us the opportunity of studying this valuable and very rich material.

Indonesian desmids, of course, belong to the Indo-Malayan-North Australian desmid-flora, which also extends into the Philippines, and a few species even to Japan; other species are found also in tropical Africa, some are pan-tropical, and many are cosmopolitan, so that for identification a large number of books and papers must be consulted, as will be evident from our extensive bibliography. Ecological and edaphic data on some of the localities represented in these collections are given by VAAS (1952); VAAS & SACHLAN (1949, 1952, 1955); VAAS, SACHLAN & WIRAATMADJA (1953). ZANEVELD (1951) has reviewed three centuries of marine and freshwater phycological work and collectors in Indonesia, with a complete bibliography up to 1950.

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## Kalimantan (Borneo)

| No. | Habitat. | Collector. | Date. | |
|---|---|---|---|---|
| A. | A swamp near Bandjarmasin, S. Borneo | B. M. Hoeks | | 1941 |
| H. | Kenohan Djempang, S. Borneo | „ | | „ |
| S. | Squeezings from Sphagnum, River Kapuas region, W. Borneo | K. F. Vaas | June | 1949 |
| X. | A lake in E. Borneo | „ | „ | 1941 |
| 38. | Lake Semedo, W. Borneo. pH 5.5-6.0 | „ | „ | 1949 |
| 38A. | „ „ „ | „ | „ | „ |
| 270. | Lake Empangau, W. Borneo. pH 5.0-5.5 | „ | „ | „ |
| 108-135-146. | One tube. Situ Tawang, River Kapuas region, W. Borneo | „ | „ | „ |
| 206-212. | One tube. Danau Luar, W. Borneo. pH 5.5 | „ | „ | „ |
| 213. | Danau Luar, W. Borneo | „ | „ | „ |
| 134. | Several lakes, River Kapuas region, W. Borneo. pH 5.0-5.5 | „ | „ | „ |
| 43. | Lake Tajan, River Kapuas region, W. Borneo. pH 5.0-5.5 | „ | „ | „ |
| 401. | Swamp along the river Bangan, S. of village of Muara Muntai, S. Borneo | „ | July | 1952 |
| 402. | Same habitat as 401. | „ | „ | „ |
| 403. | Danau Panggang, near Amuntai, 150 km N. of Bandjarmasin, S. Borneo | Unknown | | 1953 |
| 404. | Fishpond at Sekadau, on Kapuas River, W. Borneo. pH 5.5 | M. Sachlan | August | 1956 |
| 405. | Fishpond at Andjungan, 60 km NE of Pontianak, W. Borneo, pH 6.5 | „ | „ | „ |
| 406. | Fishpond near Andjungan, W. Borneo, pH 6.5 | „ | „ | „ |

## Java.

| No. | Habitat. | Collector. | Date. | |
|---|---|---|---|---|
| P. | Swamp Tembaga, near Djakarta. pH 6.0-6.5 | M. Sachlan | | 1941 |
| K. | Swamp Tembaga, near Djakarta. | „ | | „ |

| | | | |
|---|---|---|---|
| O. Laboratory pond, Bogor. pH 6.5-7.0 | M. SACHLAN | May | 1942 |
| Z. „ „ „ | „ | „ | „ |
| T. A lake in the environs of Bogor. pH 6.5-7.0 | „ | „ | „ |
| M & P. A mixture of 2 collections from Tembaga Swamp, near Djakarta | „ | | 1941 |
| 501. Situ Los, a lake in Pengalengan, W. Java, elev. 1400 metres, plankton collection. pH 6.5 | „ | Nov. | 1951 |
| 501A. Situ Los, squeezings from *Hydrilla* pH 6.5 | „ | Nov. | 1951 |
| 502. Situ Tjibuntu, a lake near Situ Los. Plankton. pH 6.5 | „ | „ | „ |
| 503. Situ Gunung Putri, a lake in the environs of Bogor. Squeezings from *Utricularia* pH 6.5-7.0 | „ | March | 1951 |
| 504. A new artificial pit near experimental pond, Bogor. pH 6.5-7.0 | „ | March | 1950 |
| 505. Pond near Pengalengan, W. Java. Elev. 1300 metres. pH 6.5 | „ | April | 1954 |

BALI.

| | | | |
|---|---|---|---|
| F. Lake Bratan, Island of Bali. Elev. 1231 metres. pH 6.5-6.8 | „ | Sept. | 1950 |

SUMATRA.

| | | | |
|---|---|---|---|
| 100. Lebak Danau, a lake in the boggy environs of Palembang, S. Sumatra. pH 5.0-5.5. Squeezings from *Hydrilla*. | M. SACHLAN | Sept. | 1950 |
| 101. Lebak Danau. Plankton. | „ | „ | „ |
| 102. River Pedamaran, a tributary of River Ogan, near Palembang. | „ | „ | „ |
| 105. Lebak Penukang, Palembang, S. Sumatra. pH 5.0-5.5 | „ | August | 1951 |
| 106. Lebak Petai, Palembang, S. Sumatra. pH 5.0-5.5 | „ | „ | „ |
| 107. Lebak Danau, Palembang, S. Sumatra. pH 5.0-5.5 | „ | „ | „ |
| 108. Danau Teloko, Palembang, S. Sumatra. pH 5.0-5.5 | „ | „ | „ |
| 109. Air Klekar (a small stream), near Palembang, S. Sumatra. | „ | „ | „ |

| | | | |
|---|---|---|---|
| 110. Swamp near Menggala, S. Sumatra. Surface plankton. pH about 6.0 | M. Sachlan | April | 1954 |
| 111. Swamp near Menggala, S. Sumatra. Squeezings from *Hydrilla*. | ,, | ,, | ,, |
| 112. Swamp Pang-pangan, near Danau Teloko, S. of Palembang. pH 5.5-6.0 | ,, | ,, | ,, |
| 113. Swamp at Batang-Toru, near Padang-Sidempuan, about 100 km S. of Lake Toba, N. Sumatra | ,, | ,, | ,, |
| 114. Mixture of 12 collections from the swamp near Menggala, the same habitat as Nos. 110 and 111. Squeezings from several aquatics. | ,, | April | 1955 |
| 115. Same habitat as No. 114. Squeezings. | ,, | July | 1957 |
| 130. Lake Kerintji, Central Sumatra, in the mountains about 75 km from the West Coast. Elev. 783 metres. pH 6.5-7.4 | ,, | March | 1954 |
| 147. Kaju-Agung, S. of Palembang, S. Sumatra. pH 6.0-6.5 | ,, | Dec. | 1956 |
| 148. Kaju-Agung, S. of Palembang, S. Sumatra. pH 6.0-6.5 | ,, | ,, | ,, |
| 149. Kaju-Agung, S. of Palembang, S. Sumatra. pH 6.0-6.5 | ,, | ,, | ,, |

The Indonesian words „Situ", „Danau", and „Kenohan" all mean „Lake" in English. „Lebak" is overflowed land on a river's flood-plain, and „Lebak Danau" is a depression in the flood-plain which remains as a pond after the water has receded to the river channel. According to the new official spelling, the combination „oe" is changed to „u", so that the river in W. Borneo formerly spelled „Kapoeas" is now „Kapuas". In Gutwinski's paper (1902) the habitat „Sitve Tjibenong pr. Bogor" seems to have been an orthographic error for „Sitoe", now „Situ", so that his var. *sitvense* of *Cosm. obsoletum* is really equivalent to var. „*lacustre*".

With the exception of the one tube from Bali, which contains few desmids, nearly all the collections can be characterized as „desmid-rich", some of them extremely so. In our examination we noticed that in the earlier samples, most of which we believe were taken with a plankton net, there seemed to be a dearth of minute species, say 15 $\mu$ or less, and this may be related to the size of the meshes of the net. However, in Vaas & Sachlan (1952) there is a photomicrograph showing the mesh of a net having irregularly rectangular to trapezoidal meshes with a width of opening given as 24 $\mu$, with which they

took a sample containing many specimens of a *Cosmarium* measuring only 10 x 10 $\mu$. In this net the woven silk strands are twice as wide as the openings. Later collections, obtained by squeezing, yielded a larger proportion of the minute species of *Cosmarium* and *Euastrum*, many of them troublesome to identify because of their simple shapes and lack of outstanding features.

Kalimantan (Borneo) possesses a wealth of large and handsome desmids, many of them not found elsewhere. The Javanese material is not quite so good, and perhaps further search for more favourable habitats would give better results. The samples from Sumatra, particularly those from the neighbourhood of Palembang, are really astonishing, and more than 70 % of the total number of taxa has been recorded from this island. A swamp near Menggala, about 100 km N. of Telukbetung, S. Sumatra, samples Nos. 110, 111, 114, 115, is also very rich in desmids, as may be seen from the frequency with which these numbers appear as habitats. Sample No. 114 originally consisted of 13 collections, (one tube broken in transit), made in different parts of the swamp from various aquatic plants such as *Utricularia*, *Cabomba*, *Najas*, *Ceratophyllum* and *Hydrilla verticillata*; the last named plant, unknown in America, appears to be common in southeast Asia and north Australia. After examination of the 12 samples they were mixed together, since there appeared to be little appreciable difference in the desmid content of any of them.

TURNER (1892) claimed 536 desmid species from India, but this figure is much too high. WEST & WEST (1902, p. 124) wrote: „We look with regret upon the fact that so many of the descriptions and figures in W. B. Turner's ‚Freshw. Algae of E. India' are deplorably insufficient and inaccurate, and also that the tendency of the author was to found a species upon inadequate grounds – often upon a somewhat crude drawing in the manuscript G. C. Wallich left in the possession of the Royal Microscopical Society. This fact has rendered doubly difficult the task of identifying many of the Indian forms we have observed from Ceylon, and, unfortunately, it has caused other observers to have been led entirely astray in their interpretation of the nature of some of his species".

We have quoted these remarks in full, because we too have experienced the same difficulty in comparing our Indonesian desmids with TURNER's illustrations; some of our species *may* be identical with his, but it is not possible to be certain because of his inexact drawings. The same criticism applies also to the illustrations in JOSHUA (1886).

The WESTS (1902) described 279 desmid species and varieties from Ceylon, from about 50 tubes of material. BERNARD (1908) had 143

desmids from Java in 15 samples, but his total is also too high, since many of his species have been reduced to synonomy by later authors. KRIEGER (1933) described 380 desmid taxa from 146 collections made in Java, Bali and Sumatra. SKUJA (1949) has about 300 desmids from the neighbourhood of Rangoon (Burma) in 200 collections.

From the 49 collections at our disposal we have recorded one new genus (*Ichthyodontum*), 235 species, 243 varieties, and 48 named forms of desmids, a total of 526 taxa of which 152, or 29 %, are new to science. The much greater richness of these samples is no doubt accounted for by the fact that the material studied by the previous authors mentioned was collected by persons who were not primarily interested in desmids; thus the habitats from which they collected probably included many that were poorly or not at all suitable for desmids, which prefer soft and slightly acid waters. On the other hand, Mr. SACHLAN is a desmid enthusiast, and has tried to find favourable habitats; in this he has evidently been quite successful.

A glance at the map of Sumatra shows that very large areas along the east coast of the island are covered by swamps, and similar conditions exist in certain parts of Kalimantan (Borneo). With the building of new roads through these formerly inaccessible regions by the various oil companies, it will no doubt be possible in the future to obtain algal collections from these unexplored places; such gatherings may be expected to add greatly to the list of freshwater algae.

We wish to thank Dr. HANNAH CROASDALE for preparing the Latin diagnoses, and Mrs. DOROTHY PERINE for inking the senior author's pencil drawings.

All dimensions are given in microns, and the following abbreviations are used: L = length; W = width; T = thickness; I = width of isthmus; ssp (*sine spinibus*) = without spines; csp (*cum spinibus*) = with spines; spr (*sine processibus*) = without processes; cpr (*cum processibus*) = with processes.

A portion of the material from each of these collections has been deposited in the Farlow Herbarium of Harvard University.

The types of the new taxa are designated as the illustrations and descriptions accompanying each of them. Where more than one figure of a single taxon is given in order to show the range of variation, all of the figures are to be considered typical.

An explanation may be desirable of small changes that we have made in the spelling of some of the botanical names. It was formerly the custom to write names of *formae* in the feminine, to agree with the gender of the Latin word *forma*. But for 25 years the International Rules of Botanical Nomenclature have stated that infraspecific epithets, when adjectival in form and not used as substantives, agree

| Genera | Indonesia | | Indonesia | | Ceylon | | Burma | | Arnhem Land | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Taxa | Percent | Taxa | Percent | Taxa | Percent | Taxa | Percent | Taxa | Percent |
| Spirotaenia | 1 | 0.2 | | | | | | | | |
| Mesotaenium | | | 2 | 0.5 | | | 1 | 0.3 | 1 | 0.4 |
| Cylindrocystis | 2 | 0.4 | 1 | 0.3 | 3 | 1.1 | | | | |
| Netrium | 2 | 0.4 | 2 | 0.5 | | | 1 | 0.3 | | |
| Gonatozygon | 3 | 0.6 | 4 | 1.0 | 2 | 0.7 | 1 | 0.3 | 2 | 0.8 |
| Penium | 3 | 0.6 | 6 | 1.6 | 16 | 5.8 | 1 | 0.3 | 1 | 0.4 |
| Closterium | 40 | 7.6 | 41 | 10.8 | 29 | 10.4 | 33 | 11.0 | 18 | 7.1 |
| Pleurotaenium | 33 | 6.3 | 21 | 5.5 | 18 | 6.5 | 14 | 4.7 | 13 | 5.1 |
| Docidium | 1 | 0.2 | 1 | 0.3 | 2 | 0.7 | | | 1 | 0.4 |
| Triploceras | 2 | 0.4 | 1 | 0.3 | 1 | 0.4 | 1 | 0.3 | 3 | 1.2 |
| Tetmemorus | 2 | 0.4 | 2 | 0.5 | 1 | 0.4 | | | 3 | 1.2 |
| Ichthyocercus | 1 | 0.2 | 1 | 0.3 | | | | | | |
| Ichthyodontum | 2 | 0.4 | | | | | | | | |
| Euastrum | 61 | 11.6 | 30 | 7.9 | 34 | 12.2 | 18 | 16.0 | 37 | 14.6 |
| Euastridium | 1 | 0.2 | | | | | | | | |
| Micrasterias | 37 | 7.0 | 15 | 3.9 | 8 | 2.8 | 7 | 2.3 | 20 | 7.9 |
| Cosmarium | 111 | 21.1 | 119 | 31.3 | 69 | 24.7 | 140 | 46.8 | 49 | 19.3 |
| Arthrodesmus | 23 | 4.4 | 7 | 1.8 | 5 | 1.8 | 6 | 2.0 | 13 | 5.1 |
| Xanthidium | 23 | 4.4 | 4 | 1.0 | 10 | 3.6 | 7 | 2.3 | 7 | 2.7 |
| Staurastrum | 145 | 28.5 | 105 | 27.6 | 62 | 22.6 | 57 | 19.0 | 69 | 27.2 |
| Oocardium | | | 1 | 0.3 | | | | | | |
| Sphaerozosma | 1 | 0.2 | 2 | 0.5 | 1 | 0.4 | 1 | 0.3 | 2 | 0.8 |
| Spondylosium | 4 | 0.8 | 2 | 0.5 | 1 | 0.4 | 3 | 1.0 | | |
| Onychonema | 4 | 0.8 | 1 | 0.3 | 2 | 0.7 | 1 | 0.3 | 3 | 1.2 |
| Hyalotheca | 4 | 0.8 | 6 | 1.6 | 5 | 1.8 | 3 | 1.0 | 2 | 0.8 |
| Groenbladia | 3 | 0.6 | | | | | | | | |
| Phymatodocis | 2 | 0.4 | | | 1 | 0.4 | 1 | 0.3 | | |
| Bambusina | 3 | 0.6 | 2 | 0.5 | 1 | 0.4 | 1 | 0.3 | 1 | 0.4 |
| Desmidium | 11 | 2.1 | 4 | 1.0 | 7 | 2.5 | 2 | 0.7 | 8 | 3.1 |
| Streptonema | 1 | 0.2 | | | | | | | 1 | 0.4 |
| Total | 526 | | 380 | | 278 | | 299 | | 254 | |

in gender with the generic name, and the example is given: *Trifolium stellatum* fa. *nanum* (not *nana*). (Art. 28 in the 1935 Rules; Art. 24 in the 1956 Code). Thus a form name, such as *Desmidium baileyi* fa. *tetragona* Nordst. is an orthographic error according to modern Rules, and should be corrected to fa. *tetragonum* (Art. 73. 1956).

Art. 73 also states that the use of the terminations *i*, *ae*, or *anus* instead of *ii*, *iae*, or *ianus*, and the reverse errors, are treated as orthographic errors. Thus the names *Cosmarium regnesi*, *Staurastrum wildemani*, and similar ones, should be written *regnesii* and *wildemanii*. This, however, does not apply to *Staurastrum sebaldi* and *pseudosebaldi*, because, as Dr. Rolf Grönblad has informed us, *sebaldi* is the genitive of Sanctus Sebaldus, for whom the plant was originally named.

## MESOTAENIACEAE

### Spirotaenia Brébisson 1844

*Spirotaenia condensata* Bréb. in Ralfs (1848). Pl. 1, Figs. 1, 2.
L 135—167; W 18—21. Hab. Sumatra 103, 148; Borneo 404.

### Cylindrocystis Meneghini 1838.

*Cylindrocystis brebissonii* Menegh. (1838). Pl. 1, Fig. 3.
L 67—75; W 14—15. Hab. Java 505.

*Cylindrocystis crassa* De Bary (1858). Pl. 1, Fig. 4.
L 21; W 11. Hab. Sumatra 107.

### Netrium (Nägeli) Itzigs. & Rothe in Rabenhorst 1856.

*Netrium digitus* (Ehrbg.) Itzigs. & Rothe (1856). Pl. 1, Fig. 5.
L 147—153; W 44—45. Hab. Sumatra 107.

*Netrium digitus* var. *lamellosum* (Bréb.) Grönbl. (1920).
L 336; W 57. Hab. Java M & P.

## GONATOZYGACEAE

### Gonatozygon De Bary 1856.

*Gonatozygon aculeatum* Hast. (1892). Pl. 1, Fig. 7.
L 126—175; W center ssp 12, csp 24—29; W pole ssp 14—15. Hab. Sumatra 148; Borneo 403.

*Gonatozygon brebissonii* De Bary (1858). Pl. 1, Fig. 8.
L 134; W max. 6; W pole 4. Hab. Sumatra 114.

*Gonatozygon monotaenium* De Bary in Rabenhorst (1856). Pl. 1, Figs. 9, 10.
Specimens from Sumatra 148; L 132—168; W center 6.5—8; W pole 8—9. One specimen from Java Z: L 473; W center 16; W pole 17. The Java specimen is about one-third longer than recorded previously.

## DESMIDIACEAE

### Penium Brébisson 1844.

*Penium cylindrus* (Ehrbg.) Bréb. in Ralfs (1848). Pl. 1, Fig. 11.
L 27—48; 8—9. Hab. Sumatra 110, 114.

*Penium spirostriolatum* Barker (1869). Pl. 1, Fig. 12.
L 143; W 15. Hab. Sumatra 114, 115.

The specimen illustrated has an unusually large number of girdle-bands (14), though there may be as many as 16, according to Krieger.

*Penium spirostriolatiforme* West & West (1902). Pl. 1, Fig. 13.
L 169—324; W center 7.5—8; W pole 8—9. Hab. Sumatra 111, 115.

In our specimens the striae follow a left-hand helix as in West & West's original illustration. Krieger's figure, copied from West & West, shows a right-hand helix, but was evidently reversed in the copying process, as is the case with many of his illustrations of asymmetrical desmids. In some of our specimens, but not all, there was a very slight constriction at about the middle of the length, not shown in West & West's figure. As nearly as could be determined there was a slight discontinuity in the striae at the point of constriction, which might, therefore, be the start of cell-division.

### Closterium Nitzsch 1817.

*Closterium abruptum* var. *angustissimum* Schm. (1902). Pl. 1, Figs. 17, 18.
L 148—222; W center 9; W pole 7. Hab. Sumatra 114, 147.

*Closterium acerosum* (Schrank) Ehrbg. (1828). Pl. 3, Fig. 1.
L 405—504; W. center 54. Hab. Java P. No striae were visible in the few specimens seen.

*Closterium acerosum* (Schrank) Ehrbg. fa. *rectum*, fa. nov. Pl. 3, Fig. 2.

Axis cellulae vere rectus, margiues laterales aeque paululumque curvati, a parte cellulae media versus polos anguste rotundatos, in cacumine incrassationem internam habentes, gradatim uniformiter attenuati. Membrana subtillissime striata, sine colore.

Axis of cell exactly straight, lateral margins uniformly and slightly curved, forming a gradual and uniform taper from the center of the cell towards the poles which are narrowly rounded and with an internal thickening at the tip. Wall very finely striate, colorless. L 677; W center 57; W pole about 12. Hab. Java M & P.

In the only specimen seen the chloroplast was decomposed and the pyrenoids not distinguishable. The striae were barely visible at a magnification of 900 x.

*Closterium baillyanum* Bréb. in Ralfs (1848). Pl. 2, Fig. 21.
Wall straw-colored, with a darker tip; closely punctate (porose), the punctae larger in the darker colored portion at each pole. Two girdle bands. L. 360; W center 39; W pole about 20. Hab. Borneo X.

*Closterium biclavatum* Börges. (1890). Pl. 2, Fig. 1.
L 470—497; W center 6; W pole 6.5. Hab. Sumatra 114.

Much longer than the original from Brazil (L 300), but the same width. The same length as specimens from Arnhem Land in North Australia.

*Closterium braunii* Reinsch (1867b). Pl. 1, Fig. 22.
Wall yellowish and very finely striate, becoming brown at the poles which are punctate.
L 687; W center 32; W pole about 14. Hab. Sumatra 114.

*Closterium calosporum* Wittr. (1869). Pl. 1, Fig. 20.
L 90; W center 11; W pole 4. Hab. Borneo A.

*Closterium cornu* Ehrbg. var. *javanicum* Gutw. (1902). Pl. 2, Fig. 18.
L 220; W center 7; W pole 2. Hab. Sumatra 148.

*Closterium cuspidatum* Bail. in Ralfs (1848). Pl. 2, Fig. 12.
L 133—146; W center 51—54; L spines 20. Hab. Sumatra 114.

In two examples there was a faint indication of a suture at the center, and in one specimen the wall was very faintly and delicately striate, which has not been reported previously. The striae could only be seen with considerable difficulty at a high magnification (900 x).

*Closterium cynthia* De Not. var. *jenneri* (Ralfs) Krieg. (1937). Pl. 1, Fig. 14.

L 68; W center 9.5. Hab. Sumatra 114. Wall smooth, colorless. Six pyrenoids, and a single rhomboidal crystal at each pole.

*Closterium dianae* Ehrbg. var. *minus* (Wille) Schröder (1897). Pl. 2, Fig. 8.
L 103; W center 10; W pole 4. Hab. Sumatra 114.

*Closterium dianae* Ehrbg. var. *pseudodianae* (Roy) Krieg. (1937). Pl. 2, Fig. 7.
L 270; W center 23; W pole 4. Hab. Sumatra 148. Slightly wider than the typical variety.

*Closterium ehrenbergii* Menegh. (1840). Pl. 2, Fig. 2.
L 420—428; W center 69—83; W pole 12—15. Hab. Borneo 403; Java Z.

*Closterium gracile* Bréb. (1839). Pl. 2, Fig. 16.
L 144; W center 6; W pole 2. Hab. Sumatra 148.

*Closterium gracile* Bréb. var. *striolatum* Krieg. (1937). Pl. 2, Fig. 17.
L 147; W center 6; W. pole 3. Hab. Sumatra 110.
Wall of older semicell pale yellow and finely striate; younger semicell colorless and no striae could be seen. Poles not flattened, and no internal thickening.

*Closterium infractum* Messik. (1929). Pl. 2, Fig. 10.
L 24; W 10. Hab. Sumatra 114.

*Closterium intermedium* Ralfs (1848). Pl. 1, Fig. 19.
L 144; W center 15; W pole 6. Hab. Java 501A.

*Closterium kuetzingii* Bréb. var. *vittatum* Nordst. (1888). Pl. 1, Fig. 23. L 414; W center 14; W pole 3. Hab. Java 501A; Sumatra 147.

*Closterium lagoense* Nordst. var. *crassius* Gutw. (1902). Pl. 2, Fig. 5.
L 170; W center 33; W pole 11. Hab. Sumatra 105.

*Closterium libellula* Focke var. *elongatum* (Krieg.) Scott & Presc. comb. nov. Pl. 2, Fig. 19.

*Syn. Cl. libellula* var. *interruptum* (West & West) Donat fa. *elongata* Krieg. (1933).
Specimen from S. Sumatra; L 400; W center 36; W pole about 20.
Specimen from E. Borneo: L 357; W center 39; W pole about 18.
Hab. Sumatra 114, 115; Borneo 404.

Krieger found his fa. *elongata* in material from N. Sumatra, and assigned it to var. *interruptum* because of the interrupted ridges of the chloroplast, but in his Monograph (p. 256) he relegated it to synonomy with var. *interruptum.* We have found three specimens with continuously ridged chloroplasts, two from S. Sumatra and one from E. Borneo, which agree almost exactly in size and shape with Krieger's illustration of fa. *elongata.* In shape it differs decidedly from any of the other forms of *Cl. libellula* shown in the Monograph, the width of the cell being constant and the margins parallel for more than half the total length. For this reason and because it occurs in widely separated places we believe it is worthy of a varietal name.

*Closterium libellula* Focke var. *intermedium* (Roy & Biss.) G. S. West (1914). Pl. 2, Fig. 20.
L 92—106—135; W center 19—21—24; W pole 9—9—12. Hab. Java 505; Sumatra 111, 114, 147, 148, 149.

*Closterium lineatum* Ehrbg. (1835). Fa. Pl. 1, Fig. 26.
L 546; W center 30; W pole 9. Hab. Borneo 38A.

*Closterium lunula* (Müll.) Nitzsch var. *massartii* (Wildem.) Krieg. (1937). Pl. 1, Fig. 29.
L 766; W center 140; W pole about 20. Hab. Sumatra 148.

*Closterium lunula* var. *massartii* (Wildem.) Krieg. fa. *nasutum* fa. nov. Pl. 1, Fig. 30.

Axis cellulae rectus aut quasi rectus; corpus ad polos angustatos rotundatos aut interdum satis truncatos abrupte attenuatus; membrana levis. Chloroplastus necnon indeterminalibia.

Axis of cell straight or very nearly so; body abruptly attenuated near the narrowed poles, which are rounded or sometimes slightly truncate; wall smooth. Chloroplast and pyrenoids indeterminable.

This should be compared with *Cl. nasutum* Nordst., from which it is distinguished by its symmetrical shape and smooth wall.
L 580—609; W center 108—110; W pole 20—21. Hab. Borneo 404; Sumatra 114.

*Closterium navicula* (Bréb.) Lütkem. (1902). Pl. 2, Fig. 13.
L 38—43; W 12—15. Hab. Sumatra 114, 147, 148, 149.

*Closterium nematodes* Josh. (1886). Pl. 2, Fig. 3.
L 267; W center 28; W inflated pole 10. Hab. Sumatra 114.

*Closterium nematodes* Josh. (1886). Fa. Pl. 2, Fig. 4.

L 345—396; W center 40; W pole 14—16. Hab. Borneo 404; Sumatra 148.

Longer and wider than the specific form, but not corresponding with either of the two named varieties, var. *proboscideum* Turn. or var. *tumidum* G. S. West.

*Closterium parvulum* Näg. var. *cornutum* (Playf.) Krieg. (1937). Pl. 2, Fig. 9.
L 125—130; W center 24; W pole 6. Hab. Borneo 404.

*Closterium porrectum* Nordst. (1870). Pl. 2, Fig. 6.
L 176; W center 21; W pole 5. Hab. Borneo T.

*Closterium porrectum* var. *angustatum* West & West (1904). Pl. 2, Fig. 14.
L 105; W center 12; W pole 5. Hab. Sumatra 114.

*Closterium pusillum* Hantzsch (1861) in Rabenhorst Alg. Eur. No. 1008, Fig. a—c. Pl. 2, Fig. 15.
L 33; W 8. Hab. Sumatra 111.

*Closterium ralfsii* Bréb. var. *hybridum* Rab. (1863). Pl. 1, Fig. 25.
L 606; W center 33; W pole 7. Hab. Sumatra 148.

*Closterium rectimarginatum* sp. nov. Pl. 1, Figs. 27, 28.

Cellulae mediocres, circa 8 vel 9-plo longiores quam latae, fusiformes, marginibus lateralibus a regione media ad polos anguste rotundatos fere rectissimis. Membrana cellulae levis, sine colore. Chloroplastus circa 8 rugis continuis longitudinalibus atque 6 pyrenoideis magnis per semicellulam praeditus.

Cells of medium size, about 8 or 9 times longer than wide, spindle-shaped, lateral margins almost perfectly straight from near the center to the narrowly rounded poles. Cell wall smooth, colorless. Chloroplast with about 8 continuous longitudinal ridges and 6 large pyrenoids per semicell.
L 202—212; W center 22—27; W pole 5—6. Hab. Java 505; Sum. 149.

*Closterium setaceum* Ehrbg. (1834). Pl. 1, Fig. 21.
L 252; W center 7.5; W pole 2. Hab. Sumatra 114.

*Closterium striolatum* Ehrbg. (1832). Pl. 2, Fig. 22.
L 207—483; W center 24—36; W pole 12—17. Hab. Borneo 38A, 402; Sumatra 114.

*Closterium striolatum* Ehrbg. var. *subtruncatum* (West & West) Krieg. (1937). Pl. 2, Fig. 23.
L 174—270; W center 24—33; W pole 11—14. Hab. Sumatra 110, 147.

*Closterium tumidum* Johnson (1895). Pl. 1, Fig. 16.
L 133; W center 21; W pole 6. Hab. Sumatra 105.

*Closterium turgidum* Ehrbg. var. *borgei* (Borge) Defl. (1924). Fa. Pl. 1, Fig. 24.

Wall yellowish, finely striate with about 6 or 7 striae in 10 μ; near the poles the striae break up into punctae (pores). Chloroplast with 6 visible ridges and many scattered pyrenoids. In the only specimen seen the poles are rounded instead of being somewhat angular. L 1280; W center 68; W pole 18. Hab. Java Z.

*Closterium validum* West & West (1902). Pl. 2, Fig. 11.
L 183—201; W center 36—37. Hab. Borneo 270.

*Closterium venus* Kütz. (1845). Pl. 1, Fig. 15.
L 63; W center 9; W pole 3. Hab. Borneo A

## Pleurotaenium Nägeli 1849.

*Pleurotaenium baculoides* (Roy & Biss.) Playf. (1907). Pl. 3, Fig. 5.
L 543; W base 25; W pole 20; I 21. Hab. Sumatra 147.

*Pleurotaenium burmense* (Josh.) Krieg. (1937) var. *longissimum* var. nov. Pl. 4, Fig. 5.

Cellulae perlongae, 22 ad 30-plo longiores quam latae. Margines semicellularum per totam longitudinem paululum undulati, ca. 16 undulationibus per semicellulam observatis. Poli truncati ca. 8 ad 10 dentes (5 vel 6 visibiles) magnos obtusos quasi conicos super apicem habentes. Membrana crassa conspicue porosa, polis velut scrobiculationibus parvis ca 2 μ diam. visis. Chloroplastus parietalis 8 vel 10 taenias amplificationibus multis, singulis unum pyrenoideum continentibus, praeditas habet.

Cells extremely long, 22—30 times longer than wide. Margins of semicells slightly undulate for the entire length, with about 16 undulations per semicell. Poles truncate, with about 8 to 10 large, blunt, slightly conical teeth projecting above the apex, of which 5 or 6 are visible. Wall thick, conspicuously porose, the pores appearing as small scrobiculations about 2 μ diameter. Chloroplast parietal with 8 or 10 bands with numerous enlargements each containing one pyrenoid.
L 1656; W base 75, W pole 60; I 57. Hab. Sumatra 148.

With its length of 1656 μ this plant is probably the longest desmid yet recorded. Only one specimen was seen in the Sumatran material, but in an unpublished collection from North Australia there are many specimens of the same form with even longer apical teeth and with lengths up to 1800 μ. The plants from both Sumatra and North Australia resemble that recorded by BORGE (1896) from Queensland as *Docidium burmense* forma, which was transferred by GRÖNBLAD (1945) to *Pleurotaenium* as *Pl. burmense* var. *borgei* Grönbl. The specific form, as illustrated by JOSHUA (1886) has much deeper undulations, but it also has the unusual feature of teeth projecting considerably beyond the apex, much like our var. *longissimum*, and a good deal further than in var. *borgei*. We have recorded (1958) a form of *Pl. burmense* from Arnhem Land, with deep undulations but with small rounded apical granules not projecting beyond the apex. In the light of later knowledge this must be considered merely as a *forma* of the species.

*Pleurotaenium coronatum* (Bréb.) Rab. var. *fluctuatum* W. West (1892). Pl. 3, Fig. 6.
L 608—731; W base 36—37; W pole 24—25; I 28. Hab. Java M & P, 504.

*Pleurotaenium coronatum* (Bréb.) Rab. var. *nodulosum* (Bréb.) W. West (1892). Pl. 3, Fig. 7.
L 670; W base 48; W pole 27; I 38. Hab. Java 504.

*Pleurotaenium coroniferum* (Borge) Krieg. (1937). Fa. Pl. 5, Fig. 1.
L 379; W base 37; W pole 21; I 24. Hab. Borneo 270.

The form illustrated differs from the type in having a smooth apex without granules. In some other specimens it was thought that there was a faint suspicion of the apical granules.

*Pleurotaenium coroniferum* (Borge) Krieg. var. *multinodosum* Scott & Presc. (1958). Pl. 5, Fig. 2.
L 407—426; W base 36; W pole 21; I 23. Hab. Borneo 270; Sumatra 147.

*Pleurotaenium ehrenbergii* (Bréb.) De Bary var. *elongatum* (W. West) West & West (1904). Fa. Pl. 3, Fig. 14.
L 480; W base 19; W pole 15: I 15. Hab. Sumatra 147.

*Pleurotaenium ehrenbergii* (Bréb.) De Bary var. *undulatum* Schaarschm. (1883). Pl. 3, Fig. 12.
L 234—258; W base 21; W pole 18—19; I 18. Hab. Sumatra 114, 115.

*Pleurotaenium elatum* (Turn.) Borge in Bernard (1909). Pl. 3, Fig. 16.

L 786—819; W base 48; W pole 48; I 37—42. Hab. Java 504; Sumatra 104.

*Pleurotaenium eugeneum* (Turn.) West & West (1904). Pl. 4, Fig. 3. L 670; W base 39; W pole 36; I 35. Hab. Java K.

*Pleurotaenium eugeneum* (Turn.) West & West fa. *constrictum* fa. nov. Pl. 4, Fig. 4.

Forma magnitudine formaque speciei similis; differens praesentia duarum constrictionum super inflationem basalem.

Similar in size and shape to the species; differs in the presence of two constrictions above the basal inflation.

L 745; W base 45; W pole 36; I 34. Hab. Borneo 404.

*Pleurotaenium kayei* (Arch.) Rab. (1868). Pl. 5, Figs. 10, 11.
L ssp 264—315; W base ssp 45, csp 66—69; W pole ssp 30—35, csp 48—54; I 27—30. Hab. Sumatra 114; also Borneo and Java.

The typical form is shown in our Fig. 10. A slightly differing form from the same collection, with less pronounced undulations, no constriction below the apex, and more nearly vertical apical spines, in shown in our Fig. 11.

*Pleurotaenium minutum* (Ralfs) Delp. (1878). Pl. 2, Fig. 24.
L 96—126; W base 10—11; W pole 9; I 9—10. Hab. Borneo 38A; Sumatra 114, 149

*Pleurotaenium minutum* (Ralfs) Delp. var. *elongatum* (West & West) Cedergren (1932). Pl. 2, Fig. 26.
L 258; W base 9; W pole 7. Hab. Sumatra 114.

*Pleurotaenium minutum* (Ralfs) Delp. var. *excavatum* Scott & Grönbl. (1957). Pl. 2, Fig. 27.
L 210; W base 9; W pole 7; W apex 4; I 7. Hab. Sumatra 147.

*Pleurotaenium minutum* (Ralfs) Delp. var. *latum* Kaiser (1931). Pl. 2, Fig. 25.
L 267—309; W base 19; W pole 15; I 16—17. Hab. Sumatra 114, 149.

*Pleurotaenium nodosum* (Bail.) Lund. (1871). Formae. Pl. 5, Figs. 3, 4.
L 286—372; W max. 51—71; W pole ssp 23—33, csp 29—42; I 20—33. Hab. Borneo 270; Sumatra 103.

*Pleurotaenium nodosum* (Bail.) Lund. var. *borgei* Grönbl. (1920). Fa. Pl. 5, Fig. 5.

A form that is relatively more slender, more deeply constricted between the prominences which are more widely spaced. The apex is elevated and rounded instead of being truncate, and the shorter apical teeth project horizontally instead of upwardly. L. 381; W max. 59; W pole ssp 27, csp 33; I 27. Hab. Sumatra 147.

*Pleurotaenium nodosum* (Bail.) Lund. var. *gutwinskii* Krieg. (1937). Pl. 5, Fig. 6.
L 363; W max. 87; W pole ssp 40, csp 48; I 35. Hab. Borneo 404.

*Pleurotaenium ovatum* Nordst. (1877). Pl. 6, Figs. 1, 2.
L 282—373; W max. 99—110; W pole 36; I 32. Hab. Java Z; Sumatra 147.

The chloroplasts are continuous parietal ribbons, each with numerous enlargements containing the pyrenoids, not in isolated irregular masses as shown by BERNARD (1908) for var. *tumidum* (Mask.) G. S. West. Our figure 2 shows a form with longer teeth than usual.

*Pleurotaenium ovatum* Nordst. var. *inermius* Möbius (1894). Pl. 6, Figs. 3, 4.
L 212—307; W max. 79—95; I 46—49. Hab. Borneo 270.

Our illustrations show two differing forms from the same collection.

*Pleurotaenium simplicissimum* Grönbl. var. *insigne* (Roll) Krieg. (1937). Pl. 3, Fig. 13.
L 830; W base 31; W pole 27; I 27. Hab. Java K.

*Pleurotaenium simplicissimum* Grönbl. var. *sumatranum* var. nov. Pl. 3, Fig. 10.

Cellulae perlongae tenuesque, circa 23-plo longiores quam latae, marginibus per totam longitudinem paululum undulatis, polis paululum dilatatis truncatis, ca. 14 granula visibilia multum elongata habentibus. Membrana porosa, inter poros multis punctis subtilibus praedita.

Cells very long and slender, about 23 times as long as wide, margins slightly undulate for the entire length, poles slightly dilated, truncate, with about 14 visible greatly elongated granules. Wall porose with many very fine punctae between the pores. L. 1227; W. base 54; W pole 44; I 42. Hab. Sumatra 148.

Except for the greater length and the elongated granules this plant resembles var. *insigne* (Roll) Krieg. (1937).

*Pleurotaenium subcoronulatum* (Turn.) West & West (1895). Fa. Pl. 4, Figs. 1, 2.

L 676—822; W base 51—61; W pole 48—55; I 45—56. Hab. Borneo 406; Java 504; Sumatra 104, 147, 148.

*Pleurotaenium trabecula* (Ehrbg.) Näg. (1849). Pl. 3, Fig. 4.
L 422—510; W base 27—31; W pole 20—21; I 21—24. Hab. Borneo A; Java 504; Sumatra 147.

*Pleurotaenium trabecula* var. *maximum* (Reinsch) Roll (1927) fa. *constrictum* fa. nov. Pl. 3, Fig. 11.

Forma a varietate typica differens duabus constrictionibus profundis super inflationem basalem.

Differs from the typical variety by having two deep constrictions above the basal inflation.
L 756; W Base 45; W pole 27; I 36. Hab. Java M & P.

*Pleurotaenium treubii* Bern. (1908). Pl. 4, Fig. 7—7d.
L 680—1052; W base 54—72; W pole 35—45; I 45—57. Hab. Borneo 270; Java Z, 504.

The thick wall of this species contains a large number of big pores, apparently about two to three $\mu$ diameter, closely spaced and irregularly disposed. When these pores on the uppermost and nearly horizontal surface of the cylindrical body are examined under a high magnification (900 x) they appear, at a high focus, as light annuli with dark centers. When the focus is lowered very slightly their appearance changes to dark annuli with light centers, the change indicating that the pore structure and its contents possess lenticular properties. When the microscope objective is lowered to focus on the sloping surface of the cylinder where the inclination is about 45° from the horizontal, there is a very clear and striking impression of almost hemispherical granules raised above the surface. This appearance is misleading, however, for when the objective is lowered still further, so as to get an optical section through the horizontal diameter of the cylinder, it is seen that there are no semicircular projections from the margins such as would be caused by hemispherical granules, and such as are shown in BERNARD's illustrations (1908, pl. 6, Figs. 98—101). The most that can be observed is that at each pore seen in optical section there is a very slight convexity on the margin, too small to be shown in a drawing without exaggeration.

In an effort to learn more about the pore structure, some of the cells were crushed under a cover-glass, and then the cover was rubbed back and forth on the slide under a finger-tip pressure as great as it was thought the glass would stand without breaking. Under this very severe treatment the semicells separated at the isthmus, the contents were expelled, and the cylinders flattened completely, but

surprisingly there were very few ruptures of the cell wall. In these flattened specimens, at the edge where the wall was folded flat upon itself, there could be seen small rectangular projections from the margin, which were interpreted as showing that a plug of mucus had been partially extruded from the pore. The wall thickness is about two μ, and the size of the pores even less, so it is impossible to see much detail, and the interpretation of the structure is more or less subjective.

In order to obtain the opinions of other desmidiologists on this curious phenomenon samples of the material were sent to Dr. ROLF GRÖNBLAD and the late Dr. W. KRIEGER, who were kind enough to send sketches showing their interpretations of the pore structure, after staining and examination with oil immersion objectives. KRIEGER'S sketch is reproduced here as our figure 7c, and GRÖNBLAD'S as fig. 7d. After KRIEGER had seen GRÖNBLAD'S he wrote that he thought it was more likely to be correct than this own. The chloroplast of the plant is in numerous parietal bands, each with many pyrenoids.

BERNARD'S original illustration of *Pl. treubii* does not show any apical granules, though there is a slight projection at each of the apical angles which we think could only be caused by granules, which he probably overlooked. KRIEGER also noted this, and stated (*in. litt.*) that he considered his assignment of *Pl. treubii* as a synonym of *Pl. trabecula* var. *maximum* was incorrect.

This plant should be compared with *Docidium* (*Pleurotaenium*) *granuliferum* Josh. (1886) which has only a single deep constriction above the base, and has no indication of any apical granules.

*Pleurotaenium tridentulum* (Wolle) W. West var. *fernaldii* Taylor (1934). Pl. 3, Fig. 15.
L 139—153; W base 7; W pole ssp 7; I 5.5. Hab. Sumatra 114, 115.

This variety is characterized by its smaller size and by having 6 apical spines instead of the usual 4. The Sumatra plants can hardly be distinguished from those that occur in southeastern U.S.A.

*Pleurotaenium truncatum* (Bréb.) Näg. (1849). Fa. Pl. 3, Fig. 8.
L 413; W base 48; W pole 27; I 45. Hab. Borneo 270.

*Pleurotaenium truncatum* var. *farquharsonii* (Roy) West & West (1904). Pl. 3, Fig. 9.
L 312—342; W base 33; W pole 22; I 28. Hab. Sumatra 147.

*Pleurotaenium undatum* sp. nov. Pl. 4, Fig. 6.

Cellulae perlongae tenuesque; ca. 20 ad 22-plo longiores quam latae. Margines per totam longitudinem profunde undulati, 11 vel 12

undulationes habentes. Poli truncati in circulo 19 vel 20 granula (9—10 visibilia), a fronte visa elongata, super apicem, autem, non eminentia ferentes. Membrana conspicue porosa aut scrobiculata. Chloroplastus e taeniis parietalibus angustis amplificationes multas, singulas unum pyrenoideum ferentes, habentibus constat.

Cells very long and slender, about 20—22 times as long as wide. Margins deeply undulate for the entire length, with 11 or 12 undulations. Poles truncate and bearing a circle of 19 or 20 granules (9 or 10 visible) which in front view are elongated but do not project above the apex. Wall conspicuously porose or scrobiculate. Chloroplast in narrow parietal ribbons with many enlargements each bearing one pyrenoid.

L 1140—1296; W base 51—60; W pole 45—57; I 39—42. Hab. Borneo 402; Sumatra 110.

The undulate shape of the cell is like that of JOSHUA's figure of *Pl. burmense*, but the apical granules are quite different, and we have not been able to find another species with this combination of characteristics.

*Pleurotaenium verrucosum* (Bail.) Lund. var. *bulbosum* Krieg. (1933). Pl. 5, Figs. 7, 8.

L 274—297; W base 34—37; W pole 24—26; I 26—30. Hab. Borneo 38; Sumatra 114.

KRIEGER's variety is based on the smaller number of rings of rectangular markings and the presence of pointed apical teeth, of which he says that four are visible. In our specimens there are five or six visible pointed teeth, and there is another form, shown in our fig. 8, of the same size and shape and the same number of rings, but with five or six visible apical granules that are not pointed.

*Pleurotaenium verrucosum* (Bail.) Lund. var. *validum* Scott & Grönbl. (1957). Pl. 5, Fig. 9.

L 432; W base 48; W pole 32; W max. 51; I 40. Hab. Borneo 43, 270.

## DOCIDIUM Brébisson 1844.

*Docidium baculum* Breb. (1844). Pl. 3, Fig. 3.

L 185; W base 10; W pole 7.5 Hab. Sumatra 114, 115.

## TRIPLOCERAS Bailey 1851.

*Triploceras gracile* Bail. (1851) fa. *curvatum* fa. nov. Pl. 6, Figs. 7, 8.

Planta a forma specifica tantummodo curvatura cellularum differt.

Differs from the specific form only in the curvature of the cells.

L csp 393; W base ssp 19; W max. csp 27; W apex csp 22; I 15. Hab. Borneo 108—135—146; Borneo 213; also from Sumatra and Java.

This curved from has been found in abundance in two Borneo collections, and in smaller numbers from many other samples from Java and Sumatra, and therefore appears to be a constant form.

*Triploceras gracile* Bail. var. *undulatum* Scott & Presc. (1958). Pl. 6, Fig. 9.
L csp 382; W base ssp 21; W max. csp 36 ;I 14. Habitat Java M & P, T.

## Ichthyocercus West & West 1897.

*Ichthyocercus longispinus* (Borge) Krieg. (1933). Pl. 6, Fig. 10; Pl. 7, Figs. 1, 2.
L to depressed apex 65—73; L csp 83—90; W base 8—12; W pole csp 22—29; I 7—8; T g.
Zygospore 20 x 26. Hab. Sumatra 107, 110, 114, 149. Our illustration, Pl. 7, Fig. 2, shows a stouter form with shorter spines, more pronounced basal inflations, and greater median constriction, of which only one example has been seen.

## Ichthyodontum Scott & Prescott 1956.

*Ichthyodontum sachlanii* Scott & Presc. (1956). Pl. 7, Fig. 3.
L csp 142—150; W max. 19—22; W pole 22—24; I about 10 x 12; T max. about 17—19. Hab. Sumatra 110, 114.

*Ichthyodontum sachlanii* var. *parorthium* Scott & Prescott (1956). Pl. 7, Figs. 4, 5.
L 132—136; W max. 22—24; W pole 17—21; I about 10 x 12; T about 20—22. Hab. Sumatra 110, 114.

## Tetmemorus Ralfs 1844.

*Tetmemorus brebissonii* (Menegh.) Ralfs var. *tenuissimus* Möbius (1892). Pl. 6, Fig. 6.
L 128; W max. 12; W pole 9; I 9; T 12. Hab. Sumatra 110.

The collection Sumatra 110 was given an especially thorough search because it is the one in which the new genus *Ichthyodontum* was found. Despite this extended search only one empty semicell of *T. brebissonii* var. *tenuissimus* was found. The wall appeared to be smooth, no punctae being visible even though specially looked for, with the exception of a ring of pores around the basal inflation

*Tetmemorus laevis* (Kütz.) Ralfs (1848). Pl. 6, Fig. 5.
L 126; W 27; I 23. Hab. Borneo 38A; Sumatra 114.

## EUASTRUM Ehrenberg 1832.

*Euastrum acanthophorum* Turn. (1892). Pl. 13, Figs. 4, 5.
L csp 34—36; W 24—29; I 6—7; T 17—18. Zygospore diam. ssp 26, csp 45. Hab. Borneo 402; Sumatra 109, 114, 148.

*Euastrum acanthophorum* Turn. fa. *minus* fa. nov. Pl. 13, Figs. 6, 7.

Forma minor quam species triente, forma ornatuque satis similis. Anguli superiores laterales apicalesque ob sinum profundiorem inter se prominentiores; margo apicalis concavus non planus.

Cells about two-thirds the size of the species; shape and ornamentation quite similar to these of the species. Upper lateral and apical angles more prominent because of the deeper sinus between them; apical margin concave instead of flat.
L ssp 20—22: csp 22—26; W 16—19; I 4—5; T 11—12. Hab. Borneo 404; Sumatra 114, 115.

*Euastrum ansatum* Ehrbg. (1832). Pl. 9, Fig. 1.
L 87—90; W 40—42; I 14; T 30. Hab. Java 505; Sumatra 110, 147.

*Euastrum ansatum* Ehrbg. var. *simplex* Ducell. (1918a). Pl. 9, Fig. 2.
L 93; W 43; I 14; T 30. Hab. Borneo 38A.

*Euastrum ansatum* Ehrbg. var. *triporum* Krieg. (1937). Pl. 9, Fig. 3.
L 75; W 41; I 12; T 27. Hab. Sumatra 104.

*Euastrum antistrophum* sp. nov. Pl. 13, Fig. 8.

Cellulae parvae, subrectangulares, longiores quam latae circa quadrante; isthmus angustus, sinus linearis, per granulum aut mucronem eminentem atque superpositum e semicellula opposita ad utramque extremitatem exteriorem clausus. Semicellulae trapezoideae, duobus lobis lateralibus necnon lobo polari subrectangularibus. Margines inferiores laterales fere recti atque quasi verticales per circa dimidium altitudinis, inde ad lobum polarem formandum introrsum atque denuo sursum abrupte curvati. Apex fere planus paululum 4-undulatus, incisionem mediam non profundam habens. Superficies semicellulae granulum geminum supraisthmiale prominens fert, granulis semicellularum oppositarum ad centrum se fere attingentibus; fert necnon infra apicem granulum utroque in latere incisionis mediae, ambobus granulis superiore in semicellula sinistrorsum, inferiore dextrorsum deflexis; necnon admodum intra utrumque

marginem lateralem ad basim lobi polaris lacuna profunda velut signo crescentico visa. Cellulae a latere visae rectangulares, apicibus truncatis, granulum prominens in utroque angulo superiore laterali praebentibus, et utroque in latere admodum supra infraque contractionem isthmialem duobus granulis magnis emarginatis, granulis e semicellulis oppositis se fere attingentibus; angulis basalibus loborum lateralium duos mucrones habentibus, mucronibus e semicellulis oppositis superpositis. Cellulae a vertice visae anguste oblongae marginibus lateralibus quasi rectis deinde ad polos anguste rotundatos abrupte convergentibus; utroque in margine laterali granulum prominens, granulis in ambobus lateribus ad latera plani medii opposita deflexis; lobo polari subrectangulari quattuor granula prominentia, duobus dextrorsum, duobus sinistrorsum versis ferente.

Cells small, subrectangular in shape, about one-quarter longer than wide; isthmus narrow, sinus linear and closed at each of the outer ends by a projecting and overlapping tooth or mucro from the opposite semicell. Semicells trapezoidal, the two lateral lobes and the polar lobe subrectangular. Lower lateral margins nearly straight and almost vertical for about half the height, thence abruptly bent inward and again upward to form the polar lobe. Apex almost flat, slightly 4-undulate, with a shallow median incision. Face of semicell bearing a prominent double supraisthmian granule, those from opposite semicells almost touching in the center; subapically a prominent granule on each side of the median incision, both granules being deflected to the left in the upper semicell, and to the right in the lower; just inside each lateral margin at the base of the polar lobe a deep pit, showing as a crescentic marking. In side view cells subrectangular, apices truncate with a prominent granule showing at each upper lateral angle, and on each side, just above and below the isthmian contraction, two large emarginate granules, those from opposite semicells almost touching; basal angles of lateral lobes with two mucrones, those from opposite semicells overlapping. In vertical view narrowly oblong, the lateral margins almost straight then abruptly converging to the narrowly rounded poles; on each lateral margin a prominent granule, those on the two sides deflected to opposite sides of the median plane; polar lobe subrectangular and bearing four prominent granules, of which two are turned to the right and two to left. L 20—24; W 16—19; I 5—6; T 12—14. Hab. Sumatra 110, 114.

This curious little *Euastrum* is unlike any other that we are acquainted with. It is named *antistrophum* because all of its emergences are turned or twisted alternately on opposite directions.

*Euastrum bipartitum* Krieg. (1933). Pl. 13, Fig. 9.
L 28; W 19; I 6; T 13. Hab. Borneo 38A; Sumatra 149.

*Euastrum ceylanicum* (West & West) Krieg. (1937). Pl. 11, Figs. 3—5. L 44--45; W 36—39; I 10—12; T 22. Hab. Borneo 270.

This plant was fairly common in the one collection in which it was found, and the various individuals showed considerable variation in shape, as in seen in our figures. The form with wide and slightly retuse lateral lobes, Fig. 5, has a resemblance to some of the varieties of *E. spinulosum* and *E. gemmatum*, but the dichotypical specimen in Fig. 4 shows that it belongs to the same species as the form with rounded lateral lobes, and that this species is *E. ceylanicum* is shown by the vertical view, Fig. 3.

*Euastrum coralloides* Josh. var. *trigibberum* Lagerh. (1888). Pl. 13, Figs. 1, 2.

LAGERHEIM named this variety from Bengal without an illustration, but his description together with JOSHUA'S original illustration of the species is quite clear, since the only differences that he mentions are that the semicell has five facial swellings instead of four, and that the wall is colorless instead of „pale pink". BORGE (1899) recognized the variety, and gave an illustration of a specimen from Singapore, which has the same shape as the specific form but the five facial swellings of the variety. WEST & WEST (1907) thought that JOSHUA'S original figure of the species may be erroneous and that he should have shown five facial swellings instead of four. We are inclined to think that their opinion is correct. KRIEGER (1937) excluded the species as being „unsicher", but strangely he makes no mention whatever of var. *trigibberum*, either as being excluded or as a synonym of something else. We have found numerous examples of var. *trigibberum* from Borneo, Java and Sumatra, and rather curiously the Sumatran specimens are 50 % larger than those from the other two islands, but hardly distinguishable from them in any other feature. For convenience we tabulate below the dimensions of the various records:

| | Length | Width | Isthmus | Thickness |
|---|---|---|---|---|
| Specific form from Burma, JOSHUA | 40 | 30 | 13 | |
| var. *trigibberum*, Bengal, LAGERHEIM | Not given | | | |
| „ „ Singapore, BORGE | 36 | 25 | 8 | (Scaled from draw |
| „ „ Borneo, SCOTT & PRESCOTT | 36 | 27 | 7 | 17 |
| „ „ Java, „ „ | 35 | 27 | 7 | 17 |
| „ „ Sumatra „ „ | 51 | 39 | 10 | 22 |

Hab. Borneo 270; Java K; Sumatra 109, 114. 147.

*Euastrum coralloides* Josh. var. *subintegrum* West & West (1907). Fa. Pl. 13, Fig. 3.

L 29; W 22; I 6; T 15; W polar lobe 17. Hab .Sumatra 114.

This differs slightly from the Burmese plants of WEST & WEST in

that the large central swelling is smooth instead of 4-granulate; the granulation of the lateral lobes is more prominent than they show, and the whole plant is somewhat larger. Cf. also Scott & Prescott (1958, Fig. 6, No. 12) for an Australian *forma* of this variety.

*Euastrum denticulatum* (Kirchn.) Gay var. *quadrifarium* Krieg. (1933). Pl. 13, Fig. 10.
L 20; W 16; I 5; T 12. Hab. Sumatra 148.

*Euastrum denticulatum* (Kirchn.) Gay var. *quadrifarium* Krieg. (1933). Fa. Pl. 13, Fig. 11.
L 30; W 21; I 6; T 14. Hab. Sumatra 147.
A larger form than the foregoing, and with an open sinus instead of closed.

*Euastrum denticulatum* var. *quadrifarium* Krieg. fa. *incisum* Scott & Presc. (1958). Pl. 13, Fig. 12.
L 30; W 21—22; I 7; T 15. Hab. Sumatra 148.

*Euastrum didelta* Ralfs var. *bengalicum* Lagerh. (1888). Pl. 9, Figs. 5, 6.
L 126; W 67—75; I 18—21; T 33. Hab. Borneo X, 401; Sumatra 111.

*Euastrum didelta* Ralfs var. *cuneatiforme* Ducell. (1915). Pl. 9, Fig. 4.
L 97; W base 39; W pole 24; I 12; T about 27. Hab. Sumatra 110.

*Euastrum distortum* sp. nov. Pl. 13, Fig. 13.
Cellulae parvae $1\frac{1}{2}$-plo longiores quam latae, ovatae. Semicellulae semiovatae incisionem apicalem profundam interne late apertam, externe, autem, per superpositos lobulos polares anguste rotundatos clausam habentes; sinus linearis, ad extremitatem externam, autem, ad angulos basales rotundatos formandos, paululum apertus; margines laterales unam undulationem mediam inter angulos basales et polum late rotundatum praebentes; semicellula a fronte visa unam verrucam trigranulatam dextrorsus a linea media verticali in semicellula superiore, sinistrorsus in semicellula inferiore asymmetrice positam habens, granulum intramarginale parvum utroque in latere super angulos basales, necnon verrucam emarginatam prominentem in utroque lobulo polari habens; semicellula a latere visa subpyriformis, lobulis polaribus alterne dextrorsus ac sinistrorsus a linea media verticali multum tortis, verrucam emarginatam prominentem utroque in margine ad trientem altitudinis, alteram admodum infra polum, necnon duo granula intramarginalia parva supra basim habens. Semicellula a vertice visa ovata, polis late rotundatis, verrucam

emarginatam utroque in latere asymmetrice positam habens; lobi polares a vertice visi ovati, una extremitate acutissima ad latere opposita linea mediae deflexa, nonnulla granula marginalia intramarginaliaque imperfecta visa habentes.

Cells small, about $1\frac{1}{2}$ times longer than wide, oval in shape. Semicells semi-oval, with a deep apical incision that is broadly open internally but closed outwardly by the overlapping of the narrowly rounded polar lobules; sinus linear but slightly open at the outer end to form the rounded basal angles; lateral margins with one intermediate undulation between the basal angles and the broadly rounded pole; face of semicell with one tri-granulate verruca asymmetrically placed to the right of the vertical centerline in the upper semicell and to the left in the lower one, a small intramarginal granule on each side above the basal angles, and a prominent emarginate verruca on each of the polar lobules. In side view semicells subpyriforme with the polar lobules greatly twisted alternately to right and left of the vertical centerline, a prominent emarginate verruca on each margin at about one-third the height and another just below the pole, and two small intramarginal granules above the base of the semicell. In vertical view oval with broadly rounded poles and an emarginate verruca asymmetrically placed on each side; the polar lobules ovoid with one end pointed and deflected to opposite sides of the centerline, and some marginal and intramarginal granules that were imperfectly seen. L 27; W 17; I 5; T 12. Hab. Borneo 108—135—146, 206—212.

Only two specimens were found, and because of the chloroplast it was difficult to see the wall features, so it is possible that there may be more small markings in addition to those shown.

*Euastrum divergens* Josh. var. *ornatum* (Borge) Schm. (1898). Pl. 10, Fig. 7.
L 56; W ssp 54, csp 59; I 15; T 29. Hab. Borneo 403.

*Euastrum dubium* Näg. var. *ornatum* Wolosz. (1919). Pl. 13, Fig. 16.
L 30; W 22; I 5; T 13. Hab. Sumatra 148.

*Euastrum elegans* (Bréb.) Kütz. (1845). Fa. Pl. 13, Fig. 17.
L 33; W 21; I 8; T 15. Hab. Borneo 270; Sumatra 147.

*Euastrum elobatum* (Lu-d.) Roy & Biss. 1893 var. *oculatum* var. nov. Pl. 14, Fig. 1.

Varietas magnitudine formaque var. *simplici* Krieg. (1937) simillima, differens, autem, possessione lacunae profundae in incrassatione interna paululum infra apicem.

Identical in size and shape with var. *simplex* Krieg. (1937) but with the addition of a deep pit in an internal incrassation a short distance below the apex.
L 22; W 13; I 4; T about 10. Hab. Sumatra 115.

*Euastrum exile* Josh. (1886). Pl. 14, Fig. 2.
L ssp 26, csp 30; W 17; I 4. Hab. Sumatra 147.

*Euastrum flammeum* Josh. (1886). Pl. 11, Fig. 10.
L 41; W ssp 28—29, csp 32—33; I 7; T ssp 16—17. Hab. Sumatra 108, 147, 148, 149.

KRIEGER (1937) commented that this species is unsafe because of JOSHUA'S unsatisfactory illustrations, which, however, are not too bad and the actual plant is easily identifiable from them.

*Euastrum flammeum* Josh. var. *kalimantanum* var. nov. Pl. 11, Fig. 11.

Varietas magnitudine formaque speciei similis praeter sinum late apertum. Differt granulis multiplicibus vice paris spinarum in protuberationibus centralibus ambabus, necnon verrucis singulis bifidisve vice spinarum in superficie loborum lateralium, necnon verrucis 4-granulosis prominentibus a latere visis praecipue conspicuis.

Size and shape similar to those of the species, except for the sinus which is widely open. Differs in the substitution of multiple granules instead of a pair of spines on the central pair of protuberances, of single or bifid verrucae for the facial spines on the lateral lobes, and of prominent 4-granular verrucae for the spinous verrucae on the polar lobules, these subapical verrucae being especially conspicuous in the side view. L 42—43; W ssp 24—26, csp 27—30; I 7; T 16. Hab. Borneo 134, 206—212.

*Euastrum gayanum* De Toni (1889). Fa. Pl. 14, Fig. 3.
L 10; W 9.5; I 3.5; T 7. Hab .Sumatra 114.

*Euastrum gessneri* Krieg. & Bourr. (1957) var. *laticeps* var. nov. Pl. 14, Fig. 11.

Varietas maior crassiorque quam forma specifica, lobo polari relative latiore. Cellula a vertice visa subelliptica, utroque in latere protuberationem permagnam complanatamque interne paululum incrassatam habens.

Larger and stouter than the specific form, and with a relatively wider polar lobe. In vertical view subelliptical, with a very large flattened protuberance on each side that is slightly thickened internally.

L 39—42; W 31—32; I 11—12; T 21—23. Hab. Borneo 404; Sumatra 115.

*Euastrum gnathophorum* West & West (1897) var. *bulbosum* var. nov. Pl. 9, Figs. 9, 10.

Varietas quasi eadem magnitudine ac species; a fronte visa differt eo quod dentes basales ambarum semicellularum aliquantulum superpositi, quodque incisio apicalis ut canaliculus ca. per dimidium longitudinis semicellulae deorsum extendit. A latere visa differt eo quod pars superior semicellulae aliquantulum inflata, quodque apex late rotundatus non attenuatus truncatusque ut in specie.

Size about the same as in the species. In front view differs because of the slight overlapping of the basal teeth of the two semicells, and in the continuation of the apical incision as a groove about halfway down the face of the semicell. In side view differs in that the upper part of the semicell is somewhat inflated and the apex is smoothly rounded instead of being attenuated and truncate as in the species. L 61—72; W 34—38; I ca. 10; T 24—25. Hab. Borneo 38, 38A; Sumatra 109, 114.

*Euastrum incavatum* Josh. & Nordst. (1884) var. *platycephalum* var. nov. Pl. 13, Fig. 18.

Varietas magnitudina formaque speciei similis. A fronte visa differt eo quod apex planus, sine incisione media aut depressione, incrassationem, autem, internam, ferentem duas papillas minutas poros representantes, habet. Differt necnon possessione 4 ordinum lacunarum parvarum aut scrobiculationum, atque mucronum parvorum ad angulos basales. A latere visa differt possessione binorum mucronum basalium implexorum, atque incrassationum internarum subapicalium. A basi visa elliptica, polis acuminatis atque proiectione asymmetrica (mucronem basalem secundum repraesentante) sinistrorsus a polis singulis, praedita. A vertice visa quoque asymmetrice elliptica, apice latius ovato, 2 lacunas media in parte atque anulum 8 lacunarum intramarginalium circum perimetrum, atque incrassationem internam utroque in latere habente.

Size and shape similar to those of the species. In front view differs because of the flat apex with no median incision or depression but with an internal thickening bearing two minute papillae representing apical pores, and because of the presence of four rows of small pits or scrobiculations, and in the small mucrones at the basal angles. In side view differs because of the intermeshing pairs of basal mucrones and the presence of internal subapical thickenings. In view elliptical with pointed poles and an asymmetrical projection (representing the second basal mucron) to the left of the respective

poles. Vertical view asymmetrically elliptical like the basal view, with the apex showing as a broader oval with two large pits in the center and a ring of eight pits intramarginally around the perimeter, and an internal incrassation on each side. L 32; W 20; I 5—6; T 13—14. Hab. Sumatra 114, 115.

*Euastrum inornatum* sp. nov. Pl. 14, Fig. 4.

Cellulae parvae, ca. 1½-plo longiores quam latae. Cellula a fronte visa subrectangularis, apice angustato; sinus linearis, externe, autem, paululum apertus; anguli basales apicalesque singuli mucrone parvo praediti; margines laterales semicellularum primum divergentes, deinde ad lobum polarem lateralibus paululum convergentibus formandum, quasi abrupte convergentes; apex planus incisionem mediam modice profundam angustamque habens; superficies semicellulae lacunam magnam prope centrum, atque duo granula subapicalia praebens. Semicellula a latere visa sybpyriformis utroque in latere gibbum prominentem, incrassationem internam atque lacunam ferentem, habens; apex angustatus rotundusque, utroque in latere dentem subapicalem atque granulum parvum ferens. Semicellula a vertice visa polygonalis, utroque in latere par inflationum, unde margines concavi ad humeros inde ad polos obtuse acuminatos convergunt, praebens.

Cells small, about 1½ times as long as wide. In front view subrectangular with narrowed apex; sinus linear but slightly open at the exterior; basal and apical angles provided with a small mucro each; lateral margins of semicells at first diverging slightly, then rather abruptly converging to form the polar lobe which has slightly converging sides; apex flat with a moderately deep and narrow median incision; a large pit near the center of the face, and two small granules subapically. In side view semicells subpyriform with a prominent bulge on each side bearing an internal thickening and pit; apex narrowed and rounded, bearing a subapical tooth and a small granule on each side. Vertical view polygonal, a pair of swellings on each side, from which the concave margins ccnverge to shoulders and thence to the obtusely pointed poles. L 31; W 20; I 5; T 15. Hab. Sumatra 149.

Only three specimens were seen, none of them empty, and the details were seen only with considerable difficulty.

*Euastrum longicolle* Nordst. var. *capitatum* West & West (1902) fa. *minus* Scott & Prescott (1958). Pl. 8, Figs. 4, 5.
L 66—72; W 30—33; I 9—11; T 21—24; W polar lobe 19—24. Hab. Sumatra 102, 107, 108, 109, 147, 148.

Numerous examples were seen, in seven collections all from the

same general region in S. Sumatra, and there is some variation in the shape of the front view as shown in our figures. The vertical view of the Sumatran plants differs from that of the Australian ones on which this *forma* is based; in the Australian specimens the lateral lobes are smoothly rounded in vertical view, while those of the Sumatran examples are truncate or even slightly retuse. This feature should be compared with the vertical view of var. *magnaporum* next to be described.

*Euastrum longicolle* Nordst. (1887) var. *magnaporum* var. nov. Pl. 8, Fig. 1.

Cellulae magnae, ca. duplo longiores quam latae; sinus linearis prorsus inapertus. Anguli basales semicellularum membranae inflatione incrassationeque parva extra praediti; margines laterales ad lobos laterales rotundatos formandos divergentes deinde ad collum angustum formandum arcu lato abrupte convergentes, necnon ad lobum polarem ampliatum formandum denuo convergentes; anguli apicales rotundati; apex satis truncatus incisionem mediam rotundatam per duos dentes eminentes externe clausam habens. Superficies semicellulae prope centrum inflatione circulari magna lacunam centralem magnam habens praedita. Membrana crassa, in extremitates loborum grosse scrobiculata, alibi sparse porosa. Semicellula a latere visa corpus fere circulare collo longo crassoque lateribus ad angulos apicales rotundatos paululum divergentibus praeditum, necnon apice truncato habens. Corpus in sectione opticali per lineam mediam verticalem, utroque in latere protrusione cellulae membranae interna maxima profundissima solida conica, in extremitate exteriore lacunam magnam profundam contenente, praeditum. Cellula a vertica visa rectangularis, angulis rotundatis; utroque in latere incrassatio magna complanata protrusionem cellulae membranae internam profundam obconicam, in superficie externa lacunam magnam continentem, fert. Lobuli polares velut duos rectangulos contiguos, angulis rotundatis, visi.

Cells large, about twice as long as wide; sinus linear and closed throughout. Basal angles of semicells with a small outward swelling and thickening of the wall; lateral margins diverging to form the rounded lateral lobes, then rapidly converging on a wide curve to form a narrow neck, and then diverging again to form the enlarged polar lobe; apical angles rounded, apex somewhat truncate, with a rounded median incision that is closed outwardly by two projecting teeth. In the center of the face a large central swelling with a large central pit. Wall thick, coarsely scrobiculate on the extremities of the lobes, sparsely porose elsewhere. Side view of semicell showing an almost circular body with a long and thick neck whose sides diverge

slightly to the rounded apical angles; apex truncate; in optical section through the vertical centerline, on each side of the body an exceptionally large and deep, solid, conical, inward protrusion of the cell-wall containing a large and deep pit at its outer end. Vertical view rectangular with rounded angles; on each side a large flattened swelling bearing a very deep obconical inward protrusion of the wall with a large pit at the outer surface; polar lobules showing as two adjacent rectangles with rounded corners. L 123—125; W base 60—63; W polar lobe 27; I 15—16; T 36. Hab. Borneo 401; Sumatra 148.

The most noticeable feature of this variety, and also of the next one, var. *rotundilobum*, is the extraordinary internal protrusion of the call wall containing the very large and deep pit or mucus pore. Apparently PLAYFAIR (1907) intended to show something similar in the side view of his var. *australicum*; if so, his figure is not correctly drawn and does not convey a good idea of the real structure. We are not aware of a similar feature in any other desmid, and cannot even hazard a guess as to its function. Cf. *E. longicolle* fa. *minus* Bourr. (1957).

*Euastrum longicolle* Nordst. (1887) var. *rotundilobum* var. nov. Pl. 8, Figs. 2, 3.

Cellulae magnae, ca. duplo longiores quam latae; sinus introrsus inapertus, extrorsus as lobos laterales venuste rotundatos formandos late ampliatus; margines dorsales loborum lateralium ad collum angustum formandum arcu lato abrupte convergentes, lateribus colli ad lobum polarem expansum formandum sursum divergentibus. Anguli lobulorum polarium late rotundati, apice plano incisionem rotundatam per duos dentes eminentes extrorsus clausam habente; superficies semicellulae in centro inflationem ellipticam magnam, lacuna centrali magna praeditam, necnon inflationem minorem infra maiorem praebens. Membrana crassa, in extremitatibus loborum grosse scrobiculata, alibi sparse porosa. Semicellula a latere visa corpus fere circulare, collum longum crassumque marginibus subparallelis habens, praebet; angulis apicalibus late rotundatis, apice plano aut paululum retuso; semicellula praebet necnon in sectione opticali per lineam mediam verticalem, utroque in latere corporis in cellulae membrana protrusionem internam conicam solidam maximam ac profundissimam, in extremitate extreriore lacunam magnam profundamque continentem. Semicellula a vertice visa rectangularis, angulis rotundatis, marginibus concavis, praebens utroque in latere inflationem magnam complanatam aut satis retusam, quae inflatio protrusionem cellulae membrane internam profundissimam obconicam, ad superficiem externam lacuna magna praeditam fert;

lobuli polares duos rectangulos contiguos marginibus lateralibus paululum retusis rotundatis praebentes.

Cells large, about twice as long as wide; sinus closed inwardly, opening widely outwardly to form the gracefully rounded lateral lobes; dorsal margins of lateral lobes converging rapidly on a wide curve to form a narrow neck, the sides of which diverge upwardly to form the expanded polar lobe; angles of polar lobules broadly rounded, apex flat with a rounded median incision that is closed outwardly by two projecting teeth; in the center of the face a large elliptical swelling with a large central pit, and a smaller swelling beneath it. Wall thick, coarsely scrobiculate on the extremities of the lobes, sparsely porose elsewhere. Side view of semicell showing an almost circular body with a long and thick neck with subparallel margins; apical angles broadly rounded, apex flat or slightly retuse; in optical section through the vertical centerline, on each side of the body an exceptionally large and deep, solid, conical inward protrusion of the cell-wall, containing a large and deep pit at its outer end. Vertical view rectangular with rounded angles and concave margins; on each side a large flattened or somewhat retuse swelling bearing a very deep, obconical, inward protrusion of the cell-wall with a large pit at the outer surface; polar lobules showing as two adjacent rectangles with slightly retuse lateral margins and rounded corners. Hab. Sum. 109: L 92—94; W base 47—51; W pole 24; I 12—13; T 30.

Sumatra 110, 111, 147: L 117—120; W base 54—57; W pole 23—26; I 14; T 31—32.

In front view this plant shows an obvious resemblance to *E. intermedium* Cleve and its varieties, but the vertical view is quite different. Specimens from Sumatra 109, shown in our Fig. 3, are considerably shorter and of stouter habit than those from Sumatra 110, 111 and 147, our Fig. 2.

*Euastrum luetkemuelleri* Ducell. (1918b). Pl. 14, Fig. 8.
L 25—26; W 18—19; I 6; T 12. Hab. Borneo 38A; Sumatra 147.

*Euastrum luetkemuelleri* var. *carniolicum* Lutkem. Krieg. (1937). Fa. Pl. 14, Fig. 9.
L 36—39; W 24—25; I 9; T 17. Hab. Sumatra 110, 114.

*Euastrum luetkemuelleri* Ducell. var. *menggalense* var. nov. Pl. 14, Fig. 10.

Forma maior crassiorque, lobo polari relative latiore, admodum infra apicem lacuna magna elliptica, poro minore utroque in latere necnon 3 poris parvis utroque in lobo praedita. Cellula a vertice visa subelliptica, habens inflationem magnam rotundatam utroque in

latere, necnon lacunam magnam crescenticam intramarginalem intra incrassationem; habens necnon in centro superficiei apicalis duos poros parvos, 4 poris aliis circum eòs dispositis.

Larger and stouter than the specific form, and with a relatively wider polar lobe. Just below the apex a large elliptical pit, with a smaller pore on each side, and three small pores on each of the lateral lobes. In vertical view subelliptical with a large rounded swelling on each side and a large crescentic pit within the swelling; in the center of the apical surface two small pores and four other pores arranged around them. L 42; W 26; I 8—9; T 18—19. Hab. Sumatra 115.

This plant should be compared with var. *laterepunctatum* Scott & Presc. (1958) from Arnhem Land, which is of somewhat different shape and has a different punctation.

*Euastrum mirum* Behre (1956). Pl. 13, Figs. 14, 15.
L 30—42; W 20—27; I 6—7; T 17—19. Hab. Java M & P; Sumatra 103, 110, 147, 149.

In the largest form, Fig. 15, there is a large pit, seen as a crescentic marking, intramarginally on each side of the semicell at about mid-height. All specimens seen were of the asymmetrical form described by BEHRE; the symmetrical from described by us from Arnhem Land (1958) has not been found in the Indonesian material.

*Euastrum moebii* (Borge) Scott & Presc. (1960). Forma ad var. *burmense* accedens. Pl. 12, Fig. 1.
L 108—132; W 95—121; W polar lobe 66—69; I 30—39; T 53. Hab. Sumatra 104, 105, 114.

WEST & WEST (1897, Pl. 14, Figs. 19, 20) illustrated two slightly different forms of var. *burmense*. Our plant resembles their Fig. 19 rather than Fig. 20.

*Euastrum moebii* (Borge) Scott & Presc. var. *tetrachastriforme* West & West fa. *latum* Scott & Presc. (1960).
L 126—131; W base 133—135; W polar lobe 102—105; I 37—39; T 74—75. Hab. Borneo 404.

*Euastrum platycerum* Reinsch (1875). Fa. Pl. 60, Fig. 4.
L csp 45; W csp 42; I 13; T 24. Hab. Borneo 403.

Only one specimen was seen, and only the front view could be drawn. We show in dashed lines an approximate freehand vertical view.

*Euastrum praemorsum* (Nordst.) Schm. (1898). Pl. 7, Fig. 10.
L 72; W 45; I 12; O 37. Hab. Sumatra 110.

JOSHUA (1886) published *Euastrum retrorsum* from Burma, and the plant apparently has never been since. In size and shape, both in front and side views, it is quite similar to *E. praemorsum*. The name *retrorsum* refers to the fact that, in JOSHUA'S words, the lateral angles are produced and point backwards towards the apex; a similar effect is seen in *E. praemorsum*, produced by the large bifid verrucae projecting upwarts and outwards from the upper lateral lobes. Unfortunately JOSHUA'S poor illustration does not clearly show the structure of the lateral lobes, and particularly the incision separating the upper and lower lobes; had he shown this we would have no hesitation in saying that *retrorsum* and *praemorsum* are identical. KRIEGER (1937, p. 657) rejected *E. retrorsum* as unsafe, but through a *lapsus calami* he did so under the name *E. retroversum*, though he refers to the correct page and illustration of JOSHUA'S paper. The Latin words *retrorsum* and *retroversum* have identical meanings and, curiously, they are adjacent in one of the Latin dictionaries that we use. We believe that some of JOSHUA'S material is still preserved in the British Museum at London, and it would be very interesting if someone who has access to their collections would try to refind *E. retrorsum* and compare it with *E. praemorsum*.

*Euastrum prowsei* sp. nov. Pl. 15, Fig. 1. = *E. horikawae* Hinode 1960, sec Addendum on page 126.

Cellulae permagnae, ca. $1\frac{1}{4}$-plo longiores quam latae, isthmo lato, sinu angusto, intus ampliato, ad extremitatem exteriorem aperto. Lobi laterales permagni late rotundati, utroque in margine sex vel septem verrucas bifidas ad quadrifidas ferentes; apex truncatus depressionem mediam latam non profundam habens. Superficies semicellulae admodum infra centrum ornatu magno elliptico, per 12—15 verrucas emarginatas definito, praedita; pars centralis ornatus subflava (in semicellulis vetustioribus), ca. 35—40 lacunis magnis, forma irregularibus, quasi indefinite sexangulariter ordinatis praedita; uterque lobus lateralis ca. 24 verrucas bifidas ad multifidas ferens, atque uterque lobus polaris 7 vel 8 verrucas similes ferens. Cellulae a latere visae oblongae, habentes sinum modice profundum utroque in latere, habentes necnon super infraque sinum utroque in latere protuberationem magnam, margine paululum curvato crenatoque, lacunas intramarginales multas atque arcum granulorum ferente; lobus polaris per depressionem mediam in duos lobulos quasi asymmetricales divisus, utroque lobulo verrucas trifidas aut quadrifidas, 6 vel 7 marginales atque 5 vel 6 intramarginales, ferente; lobi laterales subcirculares verrucas trifidas aut quadrifidas, 12 ad 14 marginales atque 30 ad 32 intramarginales, ferentes. Cellulae a vertice visae late ellipticae, ornatu centrali ultra margines ellipsis non eminente,

sed incisione parva curvata a lobis lateralibus seiuncto; lobi 14—15 verrucas marginales atque ca. 20 intramarginales praebentes; lobus polaris subrectangularis, circum axem verticalem dextrorsus paululum tortus, quattuor depressionibus concavis in quattuor lobulos divisus unoquoque lobulo verrucas 4 vel 5 marginales atque 8 vel 9 intramarginales ferente; lobus polaris in centro nonnullos poros magnos in ellipsi ordinatos praebens.

Cells very large, about 1¼ times longer than wide; isthmus wide, sinus narrow and ampliated within, open to outer end. Lateral lobes very large and broadly rounded, bearing on each margin six or seven bifid to quadrifid verrucae, and separated from the polar lobe by a small semicircular incision; polar lobe wide, angles broadly rounded and each bearing on the margin four trifid verrucae; apex truncate with a broad shallow median depression. Just below the center of the face a large elliptical ornament bounded by 12 to 15 emarginate verrucae; central part of ornament yellowish (in older semicells) and provided with about 35 to 40 large pits of irregular shapes arranged in a somewhat indefinite hexagonal pattern; lateral lobes each bearing about 24 bifid to multifid verrucae, and 7 or 8 similar verrucae on each of the polar lobules. Side view of cells oblong, with a moderately deep sinus on each side, above and below there is on each side a large protuberance with slightly curved and crenate margin bearing numerous intramarginal pits and a curved line of granules; polar lobe with a median depression dividing it into two slightly asymmetrical lobules each of which bears 6 or 7 marginal and 5 or 6 intramarginal trifid or quadrifid verrucae; lateral lobes subcircular with about 12 to 14 marginal and 30 to 32 intramarginal trifid or quadrifid verrucae. Vertical view broadly elliptical, the central ornament not projecting beyond the margins of the ellipse, but separated from the lateral lobes by small curved incisions; lateral lobes with 14 or 15 marginal verrucae and about 20 intramarginal; polar lobe subrectangular and slightly twisted clockwise around the vertical axis, and divided into four lobules by four concave depressions, each lobule bearing 4 or 5 marginal and 8 or 9 intramarginal verrucae; in the center of the polar lobe an elliptical group of large pores. L 102—103; W 84—88; I 33—34; T 51—55. Hab. Borneo 38, 404.

Prowse (1957) published a drawing of this desmid as *E. turgidum* fa., having found it in Malayan material in 1956. We first found it in 1951, and named it on our camera lucida sketches as *E. turgidum* var. „*perornatum*" var. nov. When we informed Dr. Prowse of this he graciously gave us permission to publish it with our names as authors. Further study of the plant and comparison with the specific form of *E. turgidum* shows that it differs considerably, particularly in the side and vertical views; we believe it is entitled to specific rank,

and accordingly we take pleasure in dedicating it to Dr. PROWSE.

*Euastrum pulcherrimum* West & West (1902) var. *menggalense* var. nov. Pl. 7, Fig. 7.

Varietas a fronte latere verticeque visa speciei forma similis; differt, autem, quod aliquantum maior, quodque ordinationem aliquantulum aliam ornatus superficialis habet.

Similar to the specific form in both front, side and vertical views, but considerably larger, and with a somewhat different pattern of facial ornament. L 72; W 45; I 12; T 37. Hab. Sumatra 110.

*Euastrum quadrioculatum* West & West (1897) var. *curtum* var. nov. Pl. 14, Fig. 12.

Cellulae parvae, ca. 1½-plo longiores quam latae. Sinus linearis ad extremitatem externam per mucrones parvos ex angulis basalibus eminentes clausus. Margines laterales semicellularum 3-undulati; anguli apicales rotundati, apex fere planus incisionem mediam angustam, in fastigio per duo granula eminentia parva quasi clausam, habens; superficies admodum infra centrum par incrassationum prominentium praebens. Semicellulae a latere visae subpyriformes, incrassationem prominentem utroque in latere, apice paululum angulari, habentes. Semicellulae a vertice visae subellipticae, par incrassationum prominentium utroque in latere habentes, lobuli polares fere circulares, utroque granum eminens parvum ad incisionem apicalem habente.

Cells small, about 1½ times longer than wide. Sinus linear, closed at outer end by small mucrones projecting from the basal angles. Lateral margins of semicells 3-undulate; apical angles rounded, apex nearly flat with a narrow median incision that is almost closed at the top by two small projecting granules; just below the center of the face a pair of prominent swellings. In side view semicells subpyriform, with a prominent swelling on each side, and slightly angular apex. In vertical view subelliptical with a pair of prominent swellings on each side, polar lobules almost circular, each with a small projecting granule at the apical incision. L 27; W 18; I 5; T 13. Hab. Sumatra 147.

*Euastrum rectangulare* Fritsch & Rich (1937) var. *sumatranum* var. nov. Pl. 14, Fig. 6.

Cellulae minimae, ca. 1-1/3—plo longiores quam latae. Sinus linearis atque prorsus inapertus; anguli basales semicellulae mucronibus parvis sinum obtendentibus praediti; margines laterales ab angulis basalibus sursum divergentes, deinde profunde excavati, deinde ad angulos apicales anguste rotundatos, granulo eminente

parvo praeditos, denuo divergentes; margo apicalis fere planus depressione, autem, lato non profundo ad centrum praeditus; apex paululo latior quam basis semicellulae. Superficies semicellulae habens duo granula parva intramarginalia admodum infra apicem, habens necnon prope centrum granulum hemisphericum prominens, in semicellula superiore sinistrorsus a linea media verticali, in inferiore dextrorsus dispositum. Semicellulae a latere visae fere circulares, granulum hemisphericum utroque in latere, tria granula parva ad apicem, necnon mucronem parvum admodum super isthmum habentes. Semicellulae a vertice visae ellipticae, granulum hemisphericum prominens utroque in latere asymmetrice positum, atque granulum utroque in polo, atque quattuor granula alia intramarginalia habentes.

Cells very small, about 1—1/3 times longer than wide. Sinus linear and closed throughout; basal angles of semicell with small mucrones which overlap the sinus; lateral margins diverging upward from the basal angles, then deeply excavated, then diverging again to the narrowly rounded apical angles which are provided with a small projecting granule; apical margin nearly flat but with a wide and shallow depression in the center: width of apex slightly greater than the basal width of the semicell. Intramarginally two small granules just below the apex, and near the center of the face a prominent hemispherical granule which is displaced to the left of the vertical centerline in the upper semicell and to the right in the lower one. In side view semicells nearly circular, with a prominent hemispherical granule on each side, three small granules at the apex, and a small mucro just above the isthmus. In vertical view elliptical, with a prominent hemispherical granule asymmetrically placed on each side, a small granule at each pole, and four other granules intramarginally. L 13; W 10; I 4; T max. 10. Hab. Sumatra 148.

*Euastrum rostratum* Ralfs (1844) var. *bioculatum* var. nov. Pl. 11, Figs. 8, 9.

Varietas magnitudine formaque *E. rostrati* formae West & West (1902) similis, differt, autem, possessione paris pororum mucosorum magnorum admodum super partem mediam utriusque semicellulae.

Similar in size and shape to *E. rostratum* fa. West & West (1902) but differs in the possession of a pair of large mucus pores just above the center of each semicell.

L 48—61; W 31—42; I 7—11; T 18—24. Hab. Sumatra, 109, 110, 114, 147.

As will be seen from our illustrations there is considerable variation in size and in the relative width of the cells, the ratio L/W varying from 1.28 to 1.55. The smaller specimens agree very well with West & West's illustrations (1902) of their *formae* from Ceylon, except

for the pair of mucus pores; reference should be made to their remarks (*l.c.* pp. 154—155) concerning *E. umbonatum* (West & West) Schm. KRIEGER (1937) transferred WEST & WEST'S Ceylon *formae* to *E. umbonatum* as var. *ceylanicum*, but we cannot agree with this, nor with his treatment of *E. rostratum* as a synonym of *E. bidentatum* Näg.

*Euastrum sachlanii* sp. nov. Pl. 3, Figs. 17—19.

Cellulae mediocres paulo longiores quam latae; semicellulae perspicue trilobatae. Isthmus angustus; sinus angustus, in extremitate interiore aliquantulum ampliatus, versus partem exteriorem apertus, extremitate exteriore, autem, per spinas superpositas longas ad angulos basales ambarum semicellularum obturata. Lobi laterales rotundati, ferentes tres spinas marginales, spina infima deorsum, media horizontaliter, suprema verticaliter directa, ferentes necnon duas spinas intramarginales, inferiore interdum forsan verruca bifida, superiore verticaliter directa; lobus polaris latissimus ad fastigium paululum dilatatus, anguli apicales late rotundati, unam spinam crassum marginalem atque duas spinas intramarginales minores ferentes; apex truncatus, fere planus, incisionem mediam medice profundam apertamque necnon duos dentes parvos ad fastigium, habens; centrum superficiei incrassationem prominentem trilobatam habens. Semicellulae a latere visae obovatae, protrusionem emarginatam prominentissimam utroque in latere necnon duas spinas marginales atque tres intramarginales prope apicem habentes, lobis lateralibus circularibus spinas unam centralem atque sex marginales aut intramarginales habentibus, spina infima spinae alterius semicellulae obtendente. Semicellula a vertice visa incrassationem emarginatam prominentissimam utroque in latere praebens unde quattuor arcus profunde concavi, ad lobos laterales paululum dilatatos formandos, procedunt, extremitatibus externis loborum per duo latera fere recta ad angulum obtusum coeuntia formatis; omnes tres anguli loborum lateralium spinam unam marginalem atque unam intramarginalem ferentes; lobuli polares late elliptici, utroque unam verrucam emarginatam utroque in latere incisurae apicalis atque spinas quarum unam magnam atque quattuor minores praebente. Zygospora polygonalis, marginibus retusis, 18 spinas visibiles longas tenues e basibus inflatis orientes ferens.

Cells of medium size, a little longer than wide; semicells distinctly 3-lobed. Isthmus narrow; sinus narrow, somewhat ampliated at inner end, open toward exterior, but outer end obturated by overlapping long spines at the basal angles of the two semicells. Lateral lobes rounded and bearing three marginal spines, the lowest one pointing downward, the intermediate one horizontal, the uppermost

pointing vertically, and two intramarginal spines the lower of which may sometimes be a bifid verruca and the upper one directed vertically; polar lobe very wide and slightly dilated at the top, apical angles broadly rounded and bearing one stout marginal spine and two smaller ones intramarginally; apex truncate and nearly flat with a moderately deep and open median incision with two small teeth at the top; in the center of the face a large and prominent trolibular swelling. In side view semicells obovate with a very prominent emarginate protrusion on each side, two marginal and three intramarginal spines near the apex, lateral lobes circular with one central and six marginal or intramarginal spines, of which the lowest one overlaps that from the other semicell. In vertical view a very prominent emarginate swelling on each side, from which four deeply concave curves proceed to form the slightly dilated lateral lobes, the outer ends of which are formed by two almost straight sides meeting at an obtuse angle; at each of the three angles of the lateral lobes one marginal and one intramarginal spine; polar lobules broadly elliptical with one emarginate verruca at each side of the apical notch and each with one large and four smaller spines. Zygospore polygonal with retuse margins and bearing 18 visible long slender spines which arise from swollen bases.

L csp 48; W csp 40—44; I 9; T 24—27. Zygospore diam. ssp 33, csp 54. Hab. Sumatra 114, 147, 148.

This plant is quite distinctive and unlike any other *Euastrum*, though it obviously belongs to KRIEGER'S Sphyroides-Gruppe. It is closest to *E. sphyroides* var. *hieronymusii* (Schm.) Krieg., which is much larger and has a different spination and central ornament. We have also found *E. sachlanii* in almost identical form from North Australia (unpublished).

*Euastrum serratum* Josh. (1886). Pl. 11, Figs. 6, 7.
L 46—48; W 30—33; I 7—8; T 27. Hab. Borneo 270; Sumatra 112.

*Euastrum sinuosum* Lenorm. in Ralfs (1848) var. *capitatum* var. nov. Pl. 7, Figs. 8, 9.

Varietas magnitudine formaque varietati *dideltoidi* Krieg. similis, lobo polari, autem, multem dilatato, et in superficie incrassationes tantummodo quinque vice sex praebens.

Similar in size and shape to var. *dideltoides* Krieg., but with the polar lobe greatly dilated, and with only five facial swellings instead of six. L 61—73; W 37—47; W polar lobe 17—19; I 10—12; T 23. Hab. Borneo 270, 401, 404; Sumatra 109, 114, 147, 148.

This plant exhibits some variation in shape in the different collections, as can be seen from our illustrations, but the essential features are constant.

*Euastrum sinuosum* Lenorm. var. *ceylanicum* West & West (1902). Fa. Pl. 7, Fig. 6.
L 84—96; W 46—50; I 13—15; T 30. Hab. Borneo 270.

In shape this differs slightly from West & West's illustration, but the essential characters are identical.

*Euastrum sinuosum* Lenorm. var. *parallelum* Krieg. (1933). Pl. 9, Fig. 7.
L 54; W 29; I 10; T 18. Hab. Borneo 38A; Sumatra 110.

Krieger's original illustration of this variety gives only the outline of the front view, with no facial ornament, and without the side and vertical views, but we think he would not have assigned it to *E. sinuosum* if it did not possess the facial swellings characteristic of this species. We propose, therefore, that our present illustrations be taken as typical of var. *parallelum*, and accordingly we give an amended and more complete description.

Varietas aliquanto minor quam forma typica. Lobi laterales inferiores superioresque admodum super se iacentes ita ut margines basis semicellulae paralleli sint. Superficies semicellulae quinque inflationes poro mucoso praeditas, atque ad centrum tres poros mucosos sine inflationibus habens.

Somewhat smaller than the type. Lower and upper lateral lobes lying directly above one another, so that the margins of the base of the semicell are parallel. Five facial swellings each with a mucus pore, and centrally a group of three mucus pores without swellings

We have recorded var. *parallelum* from Mississippi, U.S.A., (Presc. & Scott 1945) but is is not quite identical with the Indonesian plants, as is only to be expected.

*Euastrum sinuosum* Lenorm. var. *reductum* West & West (1897). Fa. Pl. 9, Fig. 8.
L 46; W 32; W polar lobe 16; I 10. Hab. Sumatra 108, 109. This is proportionately somewhat shorter and wider than the type, and with more prominent lateral undulations.

*Euastrum spinulosum* Delp. (1876). Pl. 10, Fig. 3.
L 54; W 46; I 12; T 23. Hab. Java 501A.

*Euastrum spinulosum* Delp. (1876). Fa. Pl. 10, Fig. 4.
L 72; W 59; I 18; T 36. Hab. Java Z. A somewhat larger form with elliptical central rosette.

*Euastrum spinulosum* Delp. var. *bellum* var. nov. Pl. 10, Fig. 5.

Cellulae permagnae, lobis late rotundatis atque inter lobos inden-

tationibus acutis praeditae; verrucae rosularum centralium maximae.

Cells very large, with widely rounded lobes and acute indentations between them; verrucae of the central rosettes unusally large. L 84—92; W 72; I 21; T 46. Hab. Borneo H; Java Z.

*Euastrum spinulosum* Delp. var. *vaasii* var. nov. Pl. 10, Fig. 6.

Varietas ab aliis varietatibus huius speciei insignis praesentia in utraque semicellula sex verrucarum magnarum emarginatarum, una utroque in lobo inferiore ac superiore-laterale, duabus in lobo polari; hae verrucae praecipue prominentes semicellula a latere verticeque visa.

Distinguished from other varieties of this species by the presence on each semicell of six large emarginate verrucae, one each on the lower and upper lateral lobes and two on the polar lobe; these verrucae are especially prominent in the side and vertical views. L 55—60; W 51—57; I 13—15; T 28—31. Hab. Borneo 270; Java T.

*Euastrum subhypochondrum* Fritsch & Rich (1937). Fa. Pl. 10, Fig. 8. L 56; W 55; I 12; T 25. Hab. Java Z.

*Euastrum sublobatum* Bréb. in Ralfs (1848) var. *incrassatum* var. nov. Pl. 14, Fig. 13.

Cellulae parvae, ca. $1\frac{1}{2}$-plo longiores quam latae; isthmus angustus, sinus linearis atque prorsus inapertus; anguli basales rotundati, margines laterales paululum retusi atque convergentes per ca. dimidium altitudinis, inde profunde concavi, ad lobos polares expansos formandos; anguli apicales rotundati, apex recurvatus, depressionem mediam non profundam, atque incrassationem internam parvam admodum infra depressionem habens. Semicellula a latere visa elliptica, incrassationem internam parvam utroque in latere admodum infra apicem praebens; a vertice visa elliptica, lobo polari elliptico, incrassationem internam utroque in latere habente.

Cells small, about $1\frac{1}{2}$ times longer than wide; isthmus narrow, sinus linear and closed throughout; basal angles narrowly rounded, lateral margins slightly retuse and converging for about one-half the height, thence deeply concave to form the expanded polar lobe; apical angles rounded, apex recurved with a shallow median depression; just below this depression a small internal incrassation. Side view of semicell elliptical with a small internal incrassation on each side just below the apex. Vertical view elliptical, polar lobe elliptical with an internal incrassation on each side. L 17; W 11.5; I 3; T 8.5. Hab. Sumatra 107, 114.

*Euastrum sublobatum* Bréb. var. *sumatranum* var. nov. Pl. 14, Fig. 14.

Cellulae parvae, ca. 1—3/4-plo longiores quam latae; isthmus angustus, sinus linearis atque prorsus inapertus; anguli basales anguste rotundati, margines laterales fere recti atque per ca. dimidium altitudinis paululum divergentes, inde profunde concavi, lobos polares expansos formantes; anguli apicales late rotundati, apex recurvatus, depressionem mediam modice profundam habens; centrum superficiei lacunam magnam in incrassatione interna positam praebens. Semicellula a latere verticeque visa elliptica lacunam externam in incrassationem internam utroque in latere habens, lobus polaris ellipticus.

Cells small, about 1—3/4 times longer than wide; isthmus narrow, sinus linear and closed throughout; basal angles narrowly rounded, lateral margins almost straight and slightly divergent for about one-half the height, thence deeply concave to form the expanded polar lobe; apical angles broadly rounded, apex recurved with a moderately deep median depression; in the center of the face a large pit set in an internal incrassation. Side view of semicell elliptical with an external pit in an internal incrassation on each side. Vertical view elliptical with an external pit in an internal incrassation on each side, polar lobe elliptical. L 16—18; W 10—11; I 4; T 7.5. Hab. Sum. 107, 114.

*Euastrum subprojectum* sp. nov. Pl. 14, Fig. 7.

Cellulae parvae, paulo longiores quam latae, isthmo modice lato, sinu lineari atque interne inaperto, externe aperto; lobi laterales late rotundati atque ad altitudinem mediam mucronem parvum rotundatum ferentes; lobus polaris latus, marginibus lateralibus paululum convexis ac divergentibus; anguli apicales mucrone parvo rotundato praediti; apex planus, paululum undulatus, depressionem mediam modice latam habens, superficies semicellulae granulum circulare magnum in centro atque quattuor granula minora, uno in utroque lobo laterali atque utroque lobulo polari, necnon duo granula alia parva, uno in utroque latere depressionis apicalis habens. Semicellulae a latere visae ellipticae, granulum solidum prominens utroque in latere praebentes; poli rotundati, mucrone centrali atque duobus granulis subapicalibus parvis utroque in latere praediti. Semicellulae a vertice visae oblongae, granulum solidum magnum utroque in latere habentes, poli anguste rotundati, mucronem eminentem atque granulum marginale parvum utroque in latere praebentes; lobuli polares velut semiellipses visi, mucrone eminente ad polum atque duobus granulis marginalibus parvis utroque in latere praediti.

Cells small, a little longer than wide, isthmus moderately wide, sinus linear and closed internally, open to the exterior; lateral lobes broadly rounded and bearing a small rounded mucro at their mid-height; polar lobe wide, with slightly convex and divergent lateral

margins; apical angles with a small rounded mucro; apex flat and slightly undulate, with a moderately wide median depression; in the center of the face a large circular granule, and four smaller granules one on each of the lateral lobes and polar lobules; and two other small granules one on each side of the apical depression. In side view semicells elliptical with a prominent solid granule on each side; poles rounded, with a central mucro and two small subapical granules on each side. Vertical view oblong with a large solid granule on each side, poles narrowly rounded with a protruding mucro and a small marginal granule on each side; polar lobules showing as semi-ellipses with a protruding mucro at the pole and two small marginal granules on each side. L 23; W 20; I 7; T 14. Hab. Sumatra 107.

This plant bears some resemblance to *E. projectum* Turn. (1892), though it is difficult to tell from his poor illustration what the real structure of his plant was.

*Euastrum subrostratum* West & West (1896) var. *reductum* var. nov. Pl. 14, Fig. 5.

Cellulae parvae, ca. 1—1/3-plo longiores quam latae, isthmo angusto, sinu lineari, interne inaperto, externe, autem, aperto. Lobi basales late rotundati, utroque lobo duo granula intramarginalia parva ferente; lobus polaris latus, marginibus parallelis; anguli apicales anguste rotundati, utroque angulo dentem brevem conicum atque granulum parvum intramarginale ferente; apex planus, incisionem mediam parvam habens; centrum superficiei unicam lacunam in incrassatione interna praebens. Semicellula a latere visa pyriformis, habens utroque in latere inflationem magnam, lacuna externa in incrassatione interna praeditam; poli rotundati, dentem centralem atque granulum parvum utroque in latere habentes; lobi laterales circulares, quattuor granulis parvis visibilibus. Semicellula a vertice visa oblonga, habens inflationem latam utroque in latere, lacunam externam in incrassatione interna ferentem; lobuli polares subcirculares, verruca emarginata utroque in latere incisionis apicalis atque dente conico ad polum oppositum, atque granulo parvo utroque in latere praediti.

Cells small, about 1—1/3 times longer than wide, isthmus narrow, sinus linear and closed internally but open externally. Basal lobes broadly rounded and each bearing two small granules intramarginally; polar lobe wide, with parallel margins; apical angles narrowly rounded and each bearing a short conical tooth and a small intramarginal granule; apex flat with a small median incision; in the center of the face a single pit set in an internal incrassation. Side view of semicell pyriform, on each side a large swelling with an external pit set in an internal incrassation; poles rounded with a central tooth and

a small granule on each side; lateral lobes circular with four small granules visible. Vertical view oblong, with a wide swelling on each side bearing an external pit in an internal incrassation; polar lobules subcircular, with an emarginate verruca on each side of the apical incision, a conical tooth at the opposite pole, and a small granule on each side. L csp 30; W 22; I 6; T 13. Hab. Sumatra 114.

Only two specimens of this were seen, and its assignment to *E. subrostratum* is not entirely satisfactory; it may perhaps be a new species.

*Euastrum substellatum* Nordst. (1880). Formae. Pl. 11, Figs. 1, 2. L 50—57; W 53—56; I 11—12; T 25. Hab. Borneo 403; Java P; Sumatra 105, 148.

We illustrate two slightly different forms of this rather variable species.

*Euastrum subvalidum* Behre (1956). Pl. 14, Fig. 15.
L 26—27; W 18; W pole 12; I 4.5; T 12. Hab. Sumatra 114.

*Euastrum turgidum* Wall. (1860). Formae. Pl. 12, Figs. 4, 5.
L 122—132; W 100—107; I 36—40; T 60—69. Hab. Java P, Z. Cf. Scott & Prescott (1960).

*Euastrum vinnulum* sp. nov. Pl. 14, Fig. 16.

Cellulae parvae, ca. $1\frac{1}{2}$-plo longiores quam latae; isthmus angustus, sinus linearis atque intus ampliatus, externe apertus. Lobi laterales late rotundati, granula quattuor marginalia atque quinque intramarginalia ferentes; lobus polaris aliquantulum dilatatus, angulis late rotundatis utroque granula marginalia unum parvum atque unum maius ferente; apex planus, incisionem mediam modice profundam angustamque habens, granula uno parvo atque uno magno admodum infra apicem utroque in latere incisionis mediae; centrum superficiei semicellulae protrusionem circularem, quinque vel sex crenationibus marginalibus praeditam, habens. Semicellula a latere visa pyriformis, protrusionem magnam crenatam utroque in latere praebens, lobo polari rotundato, granula quattuor marginalia atque unum intramarginale ferente, lobis lateralibus circularibus granula aliquot marginalia intramarginaliaque ferentibus. Semicellula a vertice visa elliptica, inflationem emarginatem utroque in latere, et granula tria parva atque duo maiora prope utrumque polum habens; lobuli polares circulares, utroque granula tria parva duo maiora habente.

Cells small, about $1\frac{1}{2}$ times longer than wide, sinus linear and ampliated within, open to the exterior. Lateral lobes broadly rounded and bearing four marginal and five intramarginal granules; polar

lobe somewhat dilated, angles broadly rounded and each bearing one small and one larger granule marginally; apex flat with a moderately deep and narrow medican inision; just below the apex one small and one large granule on each side of the median incision; in the center of the face a circular protrusion with five or six marginal crenations. Side view of semicell pyriform, a large crenate protrusion on each side, polar lobe rounded and bearing four marginal granules and one intramarginal; lateral lobes circular with several marginal and intramarginal granules. Vertical view elliptical with an emarginate swelling on each side; and three small and two larger granules near each pole; polar lobules circular, each with three small and two larger granules. L 22; W 16—17; I 4; T 11. Hab. Sumatra 147, 148.

### Euastridium West & West 1907.

*Euastridium staurastroides* Carter (1926). Pl. 10, Figs. 1, 2.
L 100—107; W 66—67; I 33—36. Hab. Borneo 403; Sumatra 112.

Slightly larger than Carter's specimens from India, and with an open sinus instead of closed, but otherwise agreeing very well. Her illustration shows the margins crenulate and the surface scrobiculate, with larger pits on the lobes, and our observations agree with this, but in addition we found a very distinct impression that the surface is granulate, with almost hemispherical granules alternating with the deep pits. This is what we have tried to show in our illustrations, but we confess that we found it impossible to convey a true idea of the actual condition, especially because of the acute angle at which most of the surface is seen, and because in all of the four specimens seen observation of the surface features was hindered by the dense chloroplast.

### Micrasterias Agardh 1827.

*Micrasterias alata* Wall. (1860). Pl. 15, Fig. 4.
L 174—177; W 144—165; I 18—21. Hab. Java M & P, T, 505; Sumatra 148.

*Micrasterias anomala* Turn. (1892). Pl. 19, Figs. 1—4.
L 198—216; W 131—144; I 35—39; T max. 85—89; W polar lobe 86—94. Hab. Borneo 270.

*Micrasterias anomala* Turn. var. *kalimantana* var. nov. Pl. 20, Figs. 1, 2.

Varietas a specie differens processibus superficiei longioribus, necnon praecipue forma „colli" lobi polaris, latioribus infra quam supra, vice angustioris ut in delineatione originali Turneri aut vice

latidudinis fere aequae ut in figure speciminis e Singapora a West et West delineata.

Differs from the specific form in the greater length of the facial processes, and particularly in the shape of the „neck" of the polar lobe, which is wider at the bottom than at the top, instead of *vice versa* as in Turner's original illustration, or of nearly uniform width as in West & West's illustration of a specimen from Singapore. L 227—244; W 151—173; W polar lobe 114—122; I 39—20; T max. 114—126. Hab. Borneo 404.

*Micrasterias anomala* Turn. var. *reducta* var. nov. Pl. 19, Figs. 5—7.

Varietas forma var. *kalimantanae* similis, paululo minor, autem, necnon processibus brevioribus atque minus elaboratis in lobis lateralibus polaribusque ac processibus superficiei quasi ad verrucas redactis.

Similar in shape to var. *kalimantana* but somewhat smaller, with shorter and less elaborated processes on lateral and polar lobes, and with facial processes reduced to little more than verrucae. L 201—225; W 150—165; W polar lobe 91—108; I 39—45; T max. 105. Hab. Borneo 270.

*Micrasterias anomala* Turn. var. *sumatrana* var. nov. Pl. 20, Fig. 3.

Varietas forma var. *kalimantanae* similis, sed aliquantum maior ac processibus vel longioribus.

Similar in shape to var. *kalimantana*, but considerably larger and with even longer processes. L 279; W 198; W polar lobe 134; I 48; T max. 134. Hab. Sumatra 114, 115.

*Micrasterias anomala* Turn. var. *bifurcata* (Borge) Scott & Presc. comb. nov.

Syn. *Xanthidium bifurcatum* Borge (1896).

In our Arnhem Land paper (1958, but written in 1952) we published a variant *forma* of *X. bifurcatum* Borge, and commented that it should be compared with *M. anomala* and its varieties, and that the size and structure of Borge's species suggested that it may be more closely related to *Micrasterias* than to *Xanthidium*. At the time our only acquaintance with *M. anomala* was from pictures, but now that we have seen many examples of the four differing forms illustrated herein, we are convinced that Borge's Australian plants should not be assigned to *Xanthidium* but to *Micrasterias*, and accordingly we now make the transfer. Playfair's illustration of *X. bifurcatum* (1907, Pl. 4, Fig. 8), though differing somewhat from Borge's figure, also belongs with our new combination, but his Fig. 9 on the same plate, which he thought to be a young or undeveloped specimen, is not the same, and must be regarded as a different variety. Teiling (1957, p.

54) has suggested that *X. pulcherrimum* Playf. (1907, Pl. 4, Fig. 10) should probably be allocated to *Micrasterias*, and we agree with him, especially as in a new collection from Arnhem Land we have a plant (unpublished) that is almost identical in outline with *X. pulcherrimum* but with the addition of six facial processes. However, it is evident that the Australian plants are even more variable than the Indonesian ones, so it will be necssary to defer their treatment until more is known about them.

*Micrasterias apiculata* (Ehrbg.) Menegh. var. *lacerata* Turn. (1892). Pl. 18, Fig. 1.
L 249; W 184; I 37. Hab. Borneo 270.

*Micrasterias apiculata* var. *lacerata* Turn. fa. *elaborata* fa. nov. Pl. 18, Fig. 2.

Forma magnitudine formaque speciei similis; ornatus superficiei magis elaboratus. Superficies praebens admodum super infraque isthmum anulum verrucarum magnarum, in peripheria ca. 10 spinas obtusas, simplices aut furcatas ferentium, praebens necnon anulum similem sed minorem verrucarum atque spinarum furcatarum ad basim utriusque lobi polaris, necnon 8 ad 10 spinas furcatas obtusasque ad basim loborum lateralium aggregatas: reliqui lobi lobulique laterales spinas multas longas tenues acutas numerosiores quam in specie habentes.

Size and shape similar to those of the species; facial ornamentation more elaborate. Just above and below the isthmus a ring of large verrucae bearing on their periphery about 10 simple or furcate blunt spines, and a similar but smaller ring of verrucae and furcate spines at the base of each polar lobe; at the base of the lateral lobes a group of 8 to 10 furcate blunt spines; remainder of the lateral lobes and lobules with many long, slender, pointed spines which are more numerous than in the species. L 193; W 163; I 29. Hab. Borneo 38.

*Micrasterias arcuata* Bail. var. *robusta* Borge fa. *recurvata* Presc. & Scott (1952). Pl. 18, Figs. 7, 8.
L to depressed apex 38—44; L max. 49—56; W 39—45; I 8. Hab. Sumatra 149.

The discovery of this plant in Indonesia is very surprising for two reasons. The first is that in size and shape it is so close to those from Mississippi, U.S.A., as to be hardly distinguishable from them, the only appreciable difference being that in the Sumatran specimens the lateral lobes are curved upwards, while in those from the U.S.A. they are horizontal. The second reason is that the species *M. arcuata* as a whole has been regarded as being purely American (Cf. KRIE-

GER, 1939, p. 11), only one variety, var. *subpinnatifida* West & West having been reported from Angola, W. Africa

*Micrasterias ceratofera* Josh. (1885). Pl. 15, Figs. 2, 3; Pl. 22, Fig. 7. L to depressed apex 129—162; L csp 201—238; W ssp 75—93; csp 124—162; I 18—24. Hab. Borneo 38, 270; Sumatra 102, 114.

In NORDSTEDT'S Index (1896) JOSHUA'S original spelling *ceratofera* was changed to *ceratophora*, which of course is preferable; but according to the present Code the original spelling must be retained, except that orthographic or typographic errors should be corrected. In our Arnhem Land paper (1958, but written in 1952) we published a new forma *maxima* of this plant, for the reason that the dimensions of our specimens were so much greater than those given by JOSHUA. Since then we have seen many examples from several collections, and it is evident that some of JOSHUA'S dimensions must be wrong, since they do not correspond with the proportions of his drawing which agrees very well with ours. Accordingly we recommend that our fa. *maxima* be deleted.

*Micrasterias foliacea* Bail. in Ralfs (1848). Pl. 20, Fig. 4.
L max. 82; W 87; I 13; T 16. Hab. Borneo X; also common in many collections from Java and Sumatra.

*Micrasterias foliacea* Bail. var. *ornata* Nordst. (1869). Pl. 20, Fig. 5. L max. 83; W 83; I 16. Hab. Common in many collections from Borneo, Java and Sumatra.

In the Indonesian specimens of both the specific form and of var. *ornata* there is frequently seen a peculiar phenomenon that we have not seen in any American specimens. This is a warping of the surface of the filament, resulting in the twisting of the side (edge) view of the filament into a sinusoidal curve that is sometimes quite pronounced, as shown in our figure. It is caused by the curving and dishing in opposite directions of the right and left lateral lobes of one semicell, those of the other semicell being curved and dished in the reverse manner.

*Micrasterias foliacea* Bail. var. *quadrinflata* var. nov. Pl. 15, Figs. 5—8.

Varietas magnitudine formaque speciei similis, differt possessione utraque in semicellula duarum inflationum semiellipsoidearum cavarum magnarum prominentium ad basim loborum lateralium, utraque inflatione spinam longam in extremitatibus angustis ferente. Semicellula alias quattuor spinas longas, duabus utrique inflationi adiacentibus interdum habens.

Size and shape as in the specific form. Differs in the possession on each semicell of two large and prominent semiellipsoidal hollow swellings at the base of the lateral lobes, each bearing a long spine at the narrow ends. There may or may not be, in addition, four other long spines on each semicell, two adjacent to each of the swellings. L max. 69—72; W 63—72; I 12; T 15—18. Hab. Java M & P; Sumatra 107, 108.

In the vertical and basal views of the specific form and of var. *ornata* there can be seen similar but smaller swellings, but they are never visible in front view. In var. *quadrinflata*, on the contrary, the four swellings and their accompanying spines are a very prominent feature in front view.

*Micrasterias jenneri* Ralfs (1848). Pl. 22, Fig. 1.
L 185; W 132; I 27. Hab. Borneo 38A.

*Micrasterias jenneri* Ralfs var. *simplex* W. West (1890). Pl. 22, Fig. 2.
L 184; W 123; I 30. Hab. Borneo 38A.

*Micrasterias lux* Josh. (1886). Pl. 17, Figs. 1—3.
L 184—210; W 174—219; I 21—24. Hab. Borneo X; Sumatra 149.

The specific form of this plant has four apical spines on each semicell, two on the upper and two on the under surface, but we have found specimens in which one, or two, or three, or all four of these spines are missing. The spineless form is shown in our Fig. 2, which also shows a curious deformity, the entire right-hand lobe being much reduced in width.

*Micrasterias lux* Josh. var. *brevibracchiata* Behre (1956) fa. *spinosa* fa. nov. Pl. 17, Fig. 5.

Planta magnitudine formaque var. *brevibracchiatae* similis, habens, autem, ordinem spinarum parvarum per basim semicellulae, atque nonnullas spinas in lobo polari atque prope marginem contiguum lateralium.

Similar in size and shape to var. *brevibracchiata* Behre, but with the addition of a row of small spines across the base of the semicell, and a few spines on the polar lobe and near the adjacent margin of the lateral lobes. L 186—207; W 168—186; I 23—24. Hab. Sumatra 114.

*Micrasterias lux* Josh. var. *sachlanii* var. nov. Pl. 17, Fig. 4.

Varietas magnitudine speciei similis, differt, autem, eo quod uterque lobus lateralis in 10 lobulos vice 8 dividitur, differt necnon possessione ordinis spinarum per basin semicellulae, atque 4—6 spinarum in lobo polari atque 3—4 spinarum prope marginem con-

tiguum loborum lateralium, atque interdum paris spinarum parvarum in lateribus oppositis extremitatis internae incisionis lobos laterales ordinis I separantis, atque unicae spinae magnae utroque in lobo laterali ordinis II admodum infra extremitatem internam incisionis lobos ordinis III separantis.

Similar in size to the species, but with each lateral lobe divided into 10 lobules instead of 8, a row of spines across the base of the semicell, 4 to 6 large spines on the polar lobe, 3 or 4 spines near the adjacent margin of the lateral lobes, sometimes a pair of small spines on opposite sides of the inner end of the incision that separates the lateral lobes of order I, and a single large spine on each of the lateral lobes of order II just below the inner end of the incisions separating the lobes of order III. L 214—236; W 189—210; I 24—27. Hab. Sumatra 112, 149.

*Micrasterias mahabuleshwarensis* (Hobs.) var. *bengalica* (Lagerh.) Krieg. (1939). Pl. 16, Fig. 6.
L max. 126—142; W max. 102—110; W polar lobe 67—79; I 21—26; T max. 39. Hab. Borneo 403; Java T.

*Micrasterias mahabuleshwarensis* Hobs. var. *chauliodon* var. nov. Pl. 16, Figs. 3—5.

Varietas magnitudine formaque var. *dichotoma* G. M. Smith similis. Differt possessione ordinis dentium paululum curvatorum magnitudine graduatorum per basim semicellulae, necnon ordinum similium ad margines laterales lobi polaris atque ad marginem superiorem loborum lateralium ordinis II, atque circum marginem incisionis lobos laterales ordinis II separantis. Semicellula 4 verrucas subapicales bifidas longas super marginem apicalem eminentes, atque prope centrum superficiei proiectionem crassam curvatam, 2 granula parva ferentem, habens.

Similar in size and shape to var *dichotoma* G. M. Smith. Differs in the possession of a row of slightly curved teeth of graduated sizes across the base of the semicell, similar rows at the lateral margins of the polar lobe, and at the upper margin of the lateral lobes of order II, and around the margin of the incision separating the lateral lobes of order II. Subapically 4 long bifid verrucae projecting above the apical margin, and near the center of the face a stout curved conical projection bearing two small granules. L max. 138—162; W max. 112—138; W polar lobe 66—82; I 22—24; T max. 36. Hab. Borneo 38; Sumatra 114, 148.

*Micrasterias mahabuleshwarensis* Hobs. var. *surculifera* Lagerh. (1888). Pl. 16, Figs. 1, 2.

L max. 147—152; W max. 131—138; W polar lobe 87—96; I 24; T max. about 60. Hab. Java T; Sumatra 147.

*Micrasterias pinnatifida* (Kütz.) Ralfs (1848). Pl. 12, Fig. 6; Pl. 14, Figs. 17, 18.
L 54—63; W 65—70; W polar lobe 51—53; I 9—12. Hab. Borneo 403; Java Z; Sumatra 108, 147.

Two slightly differing forms are shown; Fig. 17 represents the species, while in Fig. 18 the polar lobe has only one spine on each side.

*Micrasterias pinnatifida* (Kütz.) Ralfs var. *pseudoscitans* Grönbl. (1920). Pl. 14, Fig. 19.
L 56; W 54; I 10. Hab. Borneo 270.

This seems to be the first record of this variety for the whole of Asia.

*Micrasterias quadridentata* (Nordst.) Grönbl. (1920) var. *indonesiensis* var. nov. Pl. 18, Figs. 3, 4.

Varietas a specie differens quod cellula magis elliptica, quodque forma lobi polaris alia, quattuor dentes apicales habentis, quodque incisione inter lobulos ordinis IV latiores.

Differs from the species in its more elliptical shape, the shape of the polar lobe which has four apical teeth, and by the wider incisions between the lobules of order IV. L 282—315; W 240—258; I 35—36. Hab. Borneo 38A; Sumatra 109.

*Micrasterias radians* Turn. (1892). Pl. 23, Fig. 1.
L 117—135; W 105—125; I 18—21; T 25. Hab. Borneo 134, 403.

*Micrasterias radians* Turn. var. *bogoriensis* (Bern.) G. S. West (1909). Pl. 23, Figs. 2, 3.
L 108—136; W 92—121; I 12—16. Hab. Java M & P, T; Sumatra 149.

Our Fig. 3 depicts a varying form in which the two upper lobules of order III are further divided to form lobules of order IV. All the specimens in collection Java T exhibited this peculiarity.

*Micrasterias subincisa* Krieg. (1933). Pl. 18, Fig. 5.
L 48—51; W 51—57; W polar lobe 31—39; I 9—10. Hab. Borneo X, 401.

*Micrasterias subincisa* Krieg. var. *mandibula* Krieg. (1933). Pl. 18, Fig. 6. Pl. 19, Fig. 8.
L 51—58; W 64—67; W polar lobe 42—43; I 9—10. Hab. Sumatra 108, 109, 114, 147.

*Micrasterias suboblonga* Nordst. var. *tecta* Krieg. (1933). Pl. 22, Figs. 3, 4.
L 79—89; W 64—72; W polar lobe 54—57; I 18—20; T 31. Hab. Borneo S.

The lateral lobes are more retuse and the polar lobe more convex than shown in KRIEGER'S illustration, and there is some variation among individuals, but the differences are not enough to warrant the creation of a separate variety.

*Micrasterias thomasiana* Arch. var. *evoluta* Krieg. (1933). Pl. 22, Figs. 5, 6.
L 231—234; W 195—196; I 30—33; T max. 86. Hab. Borneo 404.

Only two specimens were seen of this beautiful species.

*Micrasterias thomasiana* Arch. var. *notata* (Nordst.) Grönbl. (1920). Pl. 17, Fig. 6.
L 249—273; W 219—234; I 32—33. Hab. Java O; Sumatra 103.

*Micrasterias torreyi* Bail. var. *crameri* (Bern.) Krieg. (1939). Pl. 21, Fig. 1.
L 332—394; W 303—345; I 30—32. Hab. Java T; Sumatra 148.

Considerably larger than the maximum dimensions given by KRIEGER.

*Micrasterias torreyi* Bail. var. *curvata* Krieg. (1939). Pl. 21, Fig. 2.
L 273—327; W 198—240; I 30—39. Hab. Sumatra 112.

According to KRIEGER (1939) this variety has previously been reported only from Brazil. The Indonesian specimens seem to be quite close to var. *doveri*, from which they can be distinguished by the smaller size, the different shape of the apical part of the polar lobe, and the fact that each lateral lobe is divided into six lobes of order III instead of five.

*Micrasterias torreyi* Bail. var. *doveri* (Biswas) Krieg. (1939). Pl. 21, Fig. 3.
L 387—444; W max. 216—252; I 32—43. Hab. Borneo 402, 404; Sumatra 108, 147.

In our specimens from Borneo and Sumatra the polar lobe does not project so far beyond the lateral lobes as in shown by KRIEGER for BISWAS' specimen from the Malacca region, yet our maximum length is identical with his; this length of 444 $\mu$ is, we believe, the greatest known for any *Micrasterias*. All of our specimens were of about the same shape, and all had five lateral lobes of order III.

*Micrasterias torreyi* Bail. var. *sachlanii* var. nov. Pl. 21, Fig. 4.

Varietas magnitudine formaque varietati *doveri* similis, lobis late-

ralibus, autem, in sex lobos ordinis III, divisis, quibus lobis ipsis in 12 lobulos ordinis IV divisis.

Similar in size and shape to var. *doveri*, but with the lateral lobes divided into six lobes of order III, which are further divided into 12 lobules of order IV.

L 398; W 303; I 36. Hab. Bonorowo Swamp, Central Java.

This plant has not been seen by us; our illustration is enlarged from a very good photomicrograph made by Mr. M. SACHLAN, its discoverer, in 1941.

*Micrasterias tropica* Nordst. var. *polonica* Eichl. & Gutw. (1893) fa. *evoluta* fa. nov. Pl. 16, Fig. 7.

Planta magnitudine formaque var. *polonicae* similis, sed tenuior atque lobum polarem relative latiorem habens; pleraeque spinae faciales in verrucas bifidas effectae; semicellula inflatione centrali circulari duas ad quattuor verrucas bifidas ferente praedita.

Similar in size and shape to var. *polonica*, but of more slender habit, with a relatively wider polar lobe; with most of the facial spines developed into bifid verrucae, and provided with a central circular swelling bearing two to four bifid verrucae. L to depressed apex 108; L cpr 136; W cpr 105; I 18. Hab. Sumatra 148.

*Micrasterias zeylanica* Fritsch (1907) var. *rectangularis* var. nov. Pl. 21, Figs. 5—7.

Varietas magnitudine formaque speciei atque var. *wallichianae* (Turn.) Krieg. similis. Differt forma loborum lateralium, quorum anguli superiores-laterales valde rectangulares, haud dente brevi proprio speciei praediti, angulis basalibus etiam spina longa praeditis; lobus polaris spinis longis vice dentium brevium praeditus, latitudine tota lobi polaris cum spinis aliquantum maioribus, interdum paululo maiore quam latitudo per lobos laterales cum spinis; sinus inter lobos laterales per dimidium interius plerumque inapertus, non omnio apertus.

Similar in size and shape to the species and to var. *wallichiana* (Turn.) Krieg. Differs in the shape of the lateral lobes, of which the upper lateral angles are markedly rectangular and not provided with the short tooth that characterizes the species, and basal angles also provided with a long spine. Polar lobes with long terminal spines instead of short teeth, and total width of polar lobe with spines considerably greater, sometimes exceeding the width across the lateral lobes with spines; sinus between lateral lobes usually closed for its inner half instead of being entirely open. L 48—54; W csp 54—67; W polar lobe 56—69; I 10—12. Hab. Borneo 403; Sumatra 108.

Many examples of this variety were seen, and, as usual, there is some variation among the individuals.

## COSMARIUM Corda 1834.

*Cosmarium angulatum* (Perty) Rab. fa. *majus* Grunow (1865). Pl. 28, Fig. 1.
L 63—73; W 37—43; I 15—18; T 25—27. Hab. Java 501A; Sumatra 100, 105, 108, 148.

In empty cells there can be seen, at low magnifications, refractive spots just inside the basal and apical angles and the swellings on the lateral margins; these indicate faint surface swellings which are barely visible as slight angularities on the margins of the vertical and basal. views. Confer our remarks (1958) regarding Australian specimens of this plant.

*Cosmarium apiatum* sp. nov. Pl. 31, Fig. 18.

Cellulae parvae, ca. $1\frac{1}{4}$-plo longiores quam latae; isthmus latus, sinus late apertus; semicellulae obverse subtrapezoideae, marginibus ventralibus ad angulos superiores-laterales satis acutos late curvatis; margo apicalis paululum convexus, depressionem mediam non profundam habens; membrana levis, habens, autem, duos ordines curvatos pororum, tribus poris in superiore, quattuor in inferiore ordine. Cellulae a latere visae oblongae, constrictionem mediam non profundam praebentes, semicellulis subcircularibus. Cellulae a vertice visae subellipticae, polis acutioribus, duobus poris in centro; quattuor intra marginem.

Cells small, about $1\frac{1}{4}$ times as long as wide, sinus widely open; obversely subtrapezoidal, ventral margins widely curved to the upper angles which are rather sharp; apical margin slightly convex with a shallow median depression; wall smooth but with two curved rows of pores, three in the upper row, four in the lower. In side view cells oblong with a shallow median constriction, semicells subcircular. In vertical view subelliptical with somewhat pointed poles; two pores in the center and four others intramarginally. L 19; W 15; I 8; T 10. Hab. Sumatra 115.

*Cosmarium askenasyi* Schm. (1895). Pl. 23, Fig. 4.

| | | | | |
|---|---|---|---|---|
| Borneo 402. | L 141; | W 127; | I 56; | T 80. |
| Java T. | 163 | 129 | 55 | 81 |
| Sumatra 103 | 133 | 114 | 51 | |

*Cosmarium askenasyi* Schm. fa. *latum* Scott & Presc. (1958). Pl. 23, Fig. 5.
L 174; W 156; I 68. Hab. Borneo 404.

*Cosmarium auriculatum* Reinsch (1875). Pl. 26, Fig. 4.
L 48—50; W 58—59; I 25; T 29. Hab. Java M, P, 504.

*Cosmarium aversum* West & West (1895) var. *sumatranum* var. nov Pl. 27, Fig. 9.

Varietas paululo minor quam species. Differt forma sinus minus late aperti, atque forma semicellularum quae margines laterales rectos atque angulos apicales late rotundatos atque apicem planum habent. Cellula a vertice visa angustius elliptica quam in specie.

Slightly smaller than the species. Differs in the shape of the sinus which is less widely open, and in the shape of the semicells which have straight lateral margins, widely rounded apical angles, and a flat apex. In vertical view more narrowly elliptical than the species. L 26—27; W 18; I 5; T 12. Hab. Sumatra 111, 115.

Hirano (1956, p. 104; 1957, Pl. XX, Fig. 24) describes as *C. aversum* a plant that is of similar shape to ours, but much larger and with truncate apical angles. It differs considerably from the typical form.

*Cosmarium binerve* Lund. (1871). Pl. 28, Figs. 2, 3.
L 55—59; W 24—25; I 9—10; T 19—21. Hab. Sumatra 114, 147.

As noted in Grönblad, Prowse & Scott (1958) the „nerves" are actually grooves, not projections above the surface. In addition to the curved rows of large pits, the wall is very finely porose in these specimens, the pores being arranged regularly in decussate rows.

*Cosmarium binerve* Lund. var. *subangulatum* var. nov. Pl. 28, Fig. 4.

Varietas paululo minor quam nostra typi specimina, cellulis relative brevioribus, marginibus lateralibus concavis, angulis apicalibus magis truncatis. Membrana ornata ut in planta typica.

Slightly smaller than our specimens of the type. Differs in the relatively shorter cells, the concave lateral margins, and the more truncate apical angles. Wall ornament as in the type. L 46—51; W 23—24; I 9; T 21. Hab. Sumatra 111, 114, 115.

*Cosmarium bioculatum* Bréb. var. *hians* West & West (1897). Pl. 31, Fig. 19. L 18; W 16; I 4.5; T 9. Hab. Sumatra 115.

*Cosmarium bireme* Nordst. (1870).

| | | | | |
|---|---|---|---|---|
| Sumatra 149. | L 13; | W 12; | I 3.5: | T 9.5 |
| Sumatra 115. | 9.5 | 9 | 3 | 8 |

*Cosmarium blyttii* Wille fa. *australicum* Schm. (1896). Pl.31, Fig. 15. L 18: W 15; I 6; T 10. Hab. Sumatra 114, 147.

*Cosmarium blytii* Wille var. *novae-sylvae* West & West (1897). Pl. 31, Fig. 16. L 20; W 18; I 6. Hab. Java M & P.

*Cosmarium burkillii* West & West (1907) var. *depressum* var. nov. Pl. 30, Figs. 8, 9.

Varietas a specie differens ratione longitudinis et latitudinis ca. 1.1 vice 1.5 ita ut cellulae depressae videantur. Differens necnon ornatu superficiei, cuius singulis ad nostras figuras referre opus est.

Differs from the species in the ratio of length to width, which is about 1.1 instead of 1.5, resulting in a depressed appearance. Differs also in the facial ornament, for the details of which it is necessary to refer to our illustrations. L 36—40; W 33—36; I 11—12; T 20—21. Hab. Borneo 403; Sumatra 103.

We show two slightly differing forms of this plant, one from Borneo and the other from Sumatra. In the former the apical angles are decidedly retuse, each with a short, stout, curved spine arising from the center of the depression; in this form the facial ornament consists of small granules each surrounded by six circular pits. In the Sumatran plant the apical angles are not so retuse, and each is provided with a short stout tooth rather than a spine. Also in the Sumatran form the pits are triangular instead of circular, and there are series of parallel lines connecting the granules, probably indicating internal ribs. It may be that older semicells of the Borneo plants would also show triangular pits and ribs, as this development is known in several other species of *Cosmarium* having this pattern of ornament.

*Cosmarium ceylanicum* West & West (1902) fa. *minus* fa. nov. Pl. 31, Fig. 5.

Forma minor quam species, dentibus marginalibus promenintioribus, ornatu centrali paululo differente.

Smaller than the species; marginal teeth more prominent; central ornament somewhat different. L 28—33; W 25—27: I 7—9; T 16—17. Hab. Java T; Sumatra 148.

*Cosmarium contractum* Kirchn. (1878). Pl. 27, Fig. 4.
L 37; W 26; I 9; T 20. Hab. Sumatra 148; Bali F.

*Cosmarium contractum* Kirchn. var. *incrassatum* Scott & Presc. (1958). Pl. 27, Fig. 5.
L 44; W 32; I 8; T 24. Hab. Java T.

The semicells have a large yellowish central incrassation with larger pores, remainder of surface faintly punctate. In most of the Indonesian specimens the semicells, in front view, show a tendency towards a slight point on each lateral margin.

*Cosmarium contractum* Kirchn. var. *pachydermum* Scott & Presc. (1958). Pl. 27, Fig. 6.
L 34; W 27; I 6; T 19. Hab. Borneo X.

*Cosmarium crassangulatum* Borge var. *triverrucosum* Krieg. (1933) fa. *truncatum* fa. nov. Pl. 30, Fig. 4.

Magnitudo quasi eadem atque in varietate. Cellula a fronte visa differt eo quod margo apicalis quasi planus, dente eminente utrumque ad angulum apicalem praeditus. Cellula a latere visa differt eo quod duos dentes vice unius utrumque ad angulum basalem habet. Membrana inconspicue punctata, haud conspicue porosa.

Size about the same as that of the variety. In front view differs in that the apical margin is more nearly flat and provided with a small projecting tooth at each apical angle. In side view differs in that there are two teeth at each basal angle instead of one. Wall not conspicuously porose, but faintly punctate. L 27; W 28—29; I 7—8; T 19—21. Hab. Sumatra 114.

*Cosmarium cucurbita* Bréb. fa. *rotundatum* Krieg. (1933). Pl. 26, Fig. 6.
L 27—32; W 18; I 15. Hab. Sumatra 147, 148, 149.

*Cosmarium cucurbitinum* (Biss.) Lütkem. (1902). Pl. 23, Fig. 7.
L 69—72; W 30—33; I 28—29. Hab. Sumatra 114, 147, 148, 149.

*Cosmarium cucurbitinum* (Biss.) Lütkem. var. *longum* Scott & Grönbl. (1958). Pl. 23, Fig. 8.
L 98; W 21; I 20. Hab. Sumatra 115.

*Cosmarium cucurbitinum* (Biss.) Lütkem. var. *truncatum* Krieg. (1933). Pl. 23, Fig. 9.
L 57; W 28; I 27. Hab. Borneo 404.

*Cosmarium cuneatum* Josh. (1886). Pl. 30, Fig. 3.
L 40—42; W 45—48; I 13—14; T 24—26. Hab. Borneo 403; Sumatra 103, 108, 148.

*Cosmarium decoratum* West & West (1895). Pl. 25, Fig. 1.
L 78; W 63; I 25; T 40. Hab. Borneo 403; Sumatra 147, 148; Java T.

West & West's original illustrations of both *C. decoratum* and *C. subdecoratum* show the wall ornament of pits and granules extending over the entire surface, including the side and vertical views in the former species. In all the specimens we have seen, from both Indonesia and Australia, the triangular pits are confined to the central part of the face, and they gradually diminish in size towards the margins where they become small circular pores which also appear in the side and vertical views. Skuja's illustration of var. *dentatum* (1949) is similar to ours, while Bourrelly's figure of the

species (1957) shows the decoration over the entire surface except a small area in the center of the vertical view.

*Cosmarium denticulatum* Borge (1896) var. *ellipsoideum* var. nov. Pl. 24, Fig. 1.

Varietas differt forma cellularum, differt necnon eo quod ordinem spinarum unum marginalem ac unum intramarginalem, atque nonnullas spinas additicas in ordine tertio prope angulos basales, habet.

Differs in the shape of the cells and the fact that it has only one marginal and one intramarginal row of spines, with a few additional ones in a third row near the basal angles. L 144; W 84; I 30. Hab. Sumatra 103.

*Cosmarium depressum* (Näg.) Lund. (1871). Pl. 26, Fig. 6.
L 29—31; W 31—40; I 7—13; T 13—20. Hab. Sumatra 114, 148.

This appears to be almost identical with *C. scenedesmus* Delp. var. *punctatum* Turn. (1892), which is cited by West & West (1905) as a synonym of *C. depressum*.

*Cosmarium depressum* (Näg.) Lund. var. *apertum* (Turn.) Hirano (1956). Pl. 26, Fig. 7.
L 21—29; W 24—28; I 6—7; T 12—15. Hab. Sumatra 114, 147.

*Cosmarium dubium* Borge (1896). Pl. 32, Fig. 3.
L 27—30; W 19—21; I 5—7; T 13—15. Hab. Borneo 270; Java M & P; Sumatra 148.

*Cosmarium exasperatum* Josh. (1886). Pl. 31, Fig. 10.
L max. 34; W max. 38; I 12; T max. 24. Hab. Sumatra 108, 148.

*Cosmarium exasperatum* Josh. var. *spinatum* var. nov. Pl. 31, Fig. 11.

Varietas a specie differt possessione spinarum apicalium simplicium vice verrucarum emarginatarum; differt necnon dispositione protuberantiarum facialium, necnon possessione granuli supraisthmialis parvi utraque in semicellula.

Differs from the species in having simple apical spines instead of emarginate verrucae; also the arrangement of facial protuberances is different, and it has a small supraisthmian granule on each semicell.

*Cosmarium freemanii* West & West (1902) var. *verrucosum* var. nov. Pl. 31, Figs. 3, 4.
L max. 34; W max. 40; I 11; max. 22. Hab. Sumatra 114, 148.

Varietas quasi eadem magnitudine ac species; differt possessione quinque verrucarum intramarginalium emarginatarum vice quinque granulorum simplicium; differt quoque in nonnullis speciminibus,

possessione verrucarum emarginatarum vice duorum dentium apicalium. Ornatus facialis paululum differens.

Size about the same as that of the species. Differs in having five emarginate verrucae intramarginally instead of five simple granules, also the two apical teeth in some specimens are replaced by emarginate verrucae; facial ornament somewhat different. L 32—37; W 27—31; I 9—11; T 18—21. Hab. Borneo X, 270; Java 505; Sumatra 105, 147, 148.

In West & West's Ceylon paper (1902) there are two species that are not easy to separate, *C. freemanii* and *C. ceylanicum*, and the difficulty has been increased by the considerable variation in actual specimens from Indonesia. We have assigned these plants to *C. freemanii* largely because of the unusual grouping of the marginal teeth, namely a group of three or four teeth on the lower half of the lateral margins with the upper half devoid of teeth. The ornament in the center of the face, however, seems more like that shown by West & West for *C. ceylanicum*.

*Cosmarium geminatum* Lund. (1871) fa. *ornatum* Behre (1956). Pl. 31, Fig. 9.
L 24; W 25; I 8; T 16. Hab. Sumatra 148.

*Cosmarium globosum* Bulnh. var. *wollei* West & West (1896). Fa. Pl. 26, Figs. 10, 11.
L 29—32; W 25—27; Hab. Sumatra 107, 147.

*Cosmarium granatum* Bréb. var. *rotundatum* Krieg. (1933). Pl. 27, Fig. 17.
L 24; W 16; I 5; T 11. Hab. Borneo A.

*Cosmarium impressulum* Elfv. fa. *minus* Turn. (1892). Pl. 32, Fig. 4.
L 19; W 14; I 4; T 9. Hab. Sumatra 148.

*Cosmarium indentatum* Grönbl. var. *ellipticum* Scott & Grönbl. (1957). Pl. 27, Fig. 7.
L 30; W 25; I 5; T 13. Hab. Sumatra 100.

*Cosmarium inornatum* Josh. (1886). Pl. 26, Fig. 13.
L 32—33; W 17—18; I 13—14; T 14—15. Hab. Borneo 404; Sumatra 107, 114.

There are two pyrenoids in each semicell, as noted by Skuja (1949). The plant should be compared with *C. nipponicum* Hirano (1956, 1957), which, however, is circular in vertical view, while *C. inornatum* is broadly oval.

*Cosmarium laeve* Rab. var. *septentrionale* Wille fa. *protuberans* fa. nov. Pl. 32, Figs. 1, 2.

Forma a varietate differens quod multo maior quodque inflationem circularem parvam in centro superficiei fert.

Differs from the variety in its much larger size and the possession of a small circular swelling in the center of the face. L 39; W 26; I 9; T 17. Hab. Sumatra 110.

Our plant agrees very well in shape with West & West's illustration of var. *septentrionale* (1908, Pl. 73, Fig. 25), but it seems to us that this variety has little in common with the species and the other varieties. However, West & West (*l.c.* p. 103) stated that they had found all intermediate forms between typical *C. laeve* and var. *septentrionale.*

*Cosmarium lagerheimianum* (Turn.) Scott & Presc. comb. nov. Pl. 24, Figs. 6, 7.
L ssp 117—120; L scp 132—135; W ssp 70, csp 89—90; I 50—51. Hab. Borneo 38, 43, 404.

Turner (1892) published this as *Dysphinctium lagerheimianum* though he had referred to it (*in litt.* 1889) as *Cosmarium lagerheimianum.* His description states that the top view is broadly oval and his vertical view shows this. We have seen many specimens, and in all instances where it has been possible to get the vertical view it was exactly circular. Also he says that the wall is „*sparse sed graviter punctata*", but in all our examples there is an hexagonal group of six pits surrounding each of the conical papillae. The pits are circular, though in some instances there seems to be a tendency for them to become triangular, and they diminish in size towards the apex. Our Fig. 7. depicts a specimen from Borneo 404 in which the papillae are somewhat longer than usual and arise from an inflated base.

*Cosmarium lunatum* Wolle (1884) var. *orientale* var. nov. Pl. 32, Fig. 5.

Varietas paululo minor quam species; isthmus latior; sinus apertior; anguli basales minus acuti; margo apicalis minus convexus.

Cells somewhat smaller than the species; isthmus wider; sinus more open; basal angles less acute; apical margin less convex. L 17—21; W 18—22; I 7—8; T 9—10. Hab. Borneo S.

*Cosmarium lundellii* Delp. (1877). Pl. 25, Fig. 6.
L 66; W 69; I 31; T 36. Hab. Borneo 403.

*Cosmarium lundellii* Delp. var. *circulare* (Reinsch) Krieg. (1933). Pl. 25, Fig. 7.
L 71; W 58; I 25. Hab. Sumatra 148.

KRIEGER notes that the wall is „*nur einfach punktiert*", which agrees with our observation.

*Cosmarium lundellii* Delp. var. *corruptum* (Turn.) West & West (1902). Pl. 25, Fig. 9.
L 54; W 47; I 14; T 30. Hab. Sumatra 102.

In this variety also the wall is simply and closely punctate, all pores of the same size.

*Cosmarium lundellii* Delp. fa. *crassangulatum* fa. nov. Pl. 25, Fig. 10.

Forma a specie differens forma semicellularum, sinu late aperto, incrassatione parva membranarum ad angulos laterales. Membrana sparse porosa, omnibus poris eadem magnitudine.

Differs from the species in the shape of the semicells, the widely open sinus, and the slight thickening of the walls at the lateral angles. Wall sparsely porose, all pores of the same size. L 66—69; W 63—66; I 32—33; T 39. Hab. Java 503.

*Cosmarium lundellii* Delp. var. *ellipticum* W. West (1894). Pl. 25. Fig. 8.
L 57—69; W 46—52; I 19—22; T 27—34. Hab. Java 505; Borneo 270.

*Cosmarium maculatum* Turn. (1892). Pl. 24, Fig. 2.
L 130—174; W 72—81; I 48—51; T 59—63. Hab .Java M & P.

The wall is in two distinct layers and is strongly porose; in the center of the face each pore is surrounded by a shallow irregular pit or depression, which seem not to be visible near the margin or in side view.

*Cosmarium magnificum* Nordst. (1887) var. *granulorum* var. nov. Pl. 24, Figs. 3, 4.

Cellulae magnae, ca 1/3-plo longiores quam latae; semicellulae sub-semicirculares; isthmus latus, sinus linearis, intus paululum ampliatus, ordine curvato pororum magnorum admodum super infraque isthmum. Regio magna in centro superficiei ca. quattuor ordinibus granulorum circularium ornata, unumquidque granulum sex lacunis triangularibus sexangulariter ordinatis circumdatum, granulis lacunisque versus margines regiones imminutis. Arcus circulares verrucarum tres intramarginales atque unus marginalis hanc regionem circumdantes, ordine intimo unicum dentem ferente, proximo emarginato, ordinibus tertiis quartisque tres vel quattuor dentes parvos plerumque ferentibus. Cellula a latere visa oblongo, constrictionem mediam non profundam atque polos late rotundatos habens. Cellula a vertice visa elliptica. Chloroplastus habens quattuor

lobos quadrantales, processibus digitatoformibus multis parvis, in bases cavas verrucarum extensis, praeditos, tribus vel quattuor pyrenoideis in unoquoque quadrante.

Cells large, about one-third longer than wide; semicells sub-semicircular; isthmus wide, sinus linear and slightly ampliated within; just above and below the isthmus a curved row of large pores. A large area in the center of the face is ornamented with a pattern of about four rows of circular granules, each surrounded by six triangular pits arranged in hexagons, the granules and pits diminishing in size towards the edges of the area. Surrounding this area are three intramarginal and one marginal circular arcs of verrucae, the innermost row bearing a single tooth, the next one emarginate, the third and fourth rows usually bearing three or four small teeth. In side view oblong with a shallow median constriction and broadly rounded poles. In vertical view elliptical. Chloroplast with four quadrantal lobes, with numerous small fingerlike processes extending into the hollow bases of the verrucae, and with three or four pyrenoids in each quadrant. L 77—97; W 60—73; I 27—34; T 36—39. Hab. Borneo 403, 404; Java M & P; Sumatra 105.

This variety is similar in size and shape to var. *subcirculare* Skuja (1949), but has a different pattern of ornament.

*Cosmarium magnificum* Nordst. var. *subcirculare* Skuja (1949). Fa. Pl. 24, Fig. 5.
L 90; W 65; I 30; T 36. Hab. Borneo 270.

Only one empty semicell was seen of this form, which agrees fairly well with SKUJA's illustration, except for the central ornament, which consists of a brownish area occupied by numerous shallow pits which vary in shape from subcircular to polygonal, arranged in a vaguely hexagonal pattern.

*Cosmarium malleum* Krieg. (1933) var. *menggalense* var. nov. Pl. 32, Fig. 21.

Varietas a specie differt praecipue a latere visa eo quod protuberantiae centrales emarginatae atque super centrum semicellulae positae. Cellula a fronte visa margines laterales paululum retusos admodum infra angulos apicales praebens.

Differs from the species principally in the side view, in which the central protuberances are emarginate and located above the center of the semicell. In front view the lateral margins are slightly retuse just below the apical angles. L 15; W 16; I 8; T 13. Hab. Sumatra 114.

*Cosmarium mansangense* West & West (1907). Pl. 28, Figs. 11, 12.
L 48—70; W 21—32; I 16—23. Hab. Java 505; Sumatra 114.

*Cosmarium margaritatum* (Lund.) Roy & Biss. var. *sublatum* (Nordst.) Krieg. (1933). Pl. 29, Fig. 4.
L 69; W 64; I 24; T 36. Hab. Java Z.

*Cosmarium medioscrobiculatum* West & West var. *egranulatum* Gutw. (1902). Pl. 26, Fig. 3.
L 45; W 45; I 21; T 24. Hab. Java 504; Borneo 403.

*Cosmarium moniliforme* (Turp.) Ralfs var. *indentatum* Scott & Grönbl. (1957). Pl. 27, Fig. 10.
L 39; W 19; I 5. Hab. Sumatra 115.

*Cosmarium moniliforme* (Turp.) Ralfs var. *limneticum* West & West (1905). Pl. 27, Figs. 11, 12.
L 30—37; W 18—21; I 12—13. Hab. Sumatra 108, 148.

This is commonly seen in pairs of two attached cells, less commonly in fours, and we have seen one chain of eight cells attached.

*Cosmarium norimbergense* Reinsch fa. *depressum* West & West (1897). Pl. 32, Figs. 6, 7.
L 16—18; W 14—15; I 6; T 9. Hab. Sumatra 114, 148.

*Cosmarium nudum* (Turn.) Gutw. (1902). Pl. 30, Figs. 1, 2.
L 46—47; W 45; I 14; T 27. Hab. Sumatra 102, 148.

As Skuja (1949) has noted, there is a circular brown area with larger pores just above the center of the face, and the doubled basal angles also are brown. In side view the central thickening is seen to be lenticular in section.

*Cosmarium nymannianum* Grun. *in* Rabenhorst (1868). Pl. 27, Figs. 13, 14.
L 33—38; W 26—32; I 8—9; T 17—21. Zygospore about 39 x 33. Hab. Sumatra 147, 148, 149.

Two zygospores were seen, of golden-brown colour, roughly rectangular in shape, with about 15 large, bluntly rounded conical granules.

*Cosmarium obsoletum* (Hantzsch) Reinsch (1867). Pl. 26, Fig. 1.
L 51; W 54; I 25. Hab. Sumatra 147, 148, 149.

*Cosmarium obsoletum* (Hantzsch) Reinsch var. *sitvense* Gutw. (1902). Pl. 25, Fig. 11. Pl. 26, Fig. 2.
L 60; W 74; I 36. Hab. Sumatra 100; also many other collections from Java and Borneo.

This is one of the commonest *Cosmaria* in the Indonesian material. The two layers of the wall are easily seen, and at the basal angles the layers are separated, with a large spine extending from the inner to the outer layer. WEST & WEST interpreted this spine as a pore. Note that in the abnormal specimen on Pl. 26, Fig. 2, there are no spines in the new cell.

*Cosmarium ocellatum* Eichl. & Gutw. var. *incrassatum* West & West (1897). Pl. 32, Fig. 17.
L 24; W 19; I 4.5; T 12. Hab. Sumatra 115.

*Cosmarium ordinatum* (Boerges.) West & West var. *borgei* Scott & Grönbl. (1957). Pl. 31, Fig. 7.
L 24; W 27; I 10; T 18. Hab. Borneo 403.

*Cosmarium otus* Krieg. (1933) var. *ornatum* var. nov. Pl. 30, Fig. 5.

Varietas forma cellularum speciei similis sinu, autem, extrorsus apertiore; cellulae paululo minores quam in typo. Differt necnon eo quod ornatus centralis constat e tribus ordinibus horizontalibus granulorum circularium lacunis triangularibus atque poris parvis circumdatorum.

Shape of cells similar to that of the species, but with the sinus more open outwardly; size a little smaller than the type. Differs in the central ornament which consists of three horizontal rows of circular granules surrounded by triangular pits and small pores. L 47; W 45; I 13; T 26. Hab. Borneo X.

*Cosmarium pachydermum* Lund. (1871). Fa. Pl. 25, Fig. 5.
L 72; W 50; I 16; T 37. Hab. Sumatra 149.

The wall is scrobiculate all over, and the margins are minutely crenulate due to the pits.

*Cosmarium paucigranulatum* Borge (1923). Pl. 31, Fig. 14.
L 16; W 14; I 5; T 12. Hab. Sumatra 114.

*Cosmarium pardalis* Cohn (1874). Pl. 29, Figs. 1, 2.

| | | | | |
|---|---|---|---|---|
| Fig. 1, | L 62; | W 56; | I 18; | T about 25. |
| Fig. 2, | 66 | 66 | 24 | |

Our illustrations are drawn from specimens in COHN'S original material preserved in WITTR. & NORDST. Exsicc. No. 559. This species has not been found in Indonesia and our figures are given for comparison with *Cosmarium scabrum* Turn. (*q.v.*).

*Cosmarium peniomorphum* nom. nov. (Syn. *Penium variolatum* West & West 1897).

Krieger (1937, p. 242) pointed out that this is not a *Penium* but a *Cosmarium*, but did not make a formal transfer. A new specific epithet is neccesary because there is already a *C. variolatum*. The specific form has not been found in Indonesia, but the differing variety next to be described.

*Cosmarium peniomorphum* nob. var. *latior* var. nov. Pl. 27, Fig. 15.

Longitudo quasi eadem atque in specie, latitudo aliquante maior; margines laterales subparalleli ad polos late rotundatos vix attenuati. ad isthmum vix constricti. Membrana satis crassa, incrassationem internam parvam utrumque ad polum habens, pori in anulo admodum super infraque isthmum, alibi parce sparsi, omni poro, a sectione opticali viso, pustulam parvam („organum pori") in facie membranae interna praebente. Chloroplasti pyrenoideaque ignota quod exempla tantum vacua visa. Semicellula a vertice visa circularis.

Length about the same as in the species, width considerably greater; lateral margins subparallel, with a barely perceptible median constriction, and very little attenuation to the broadly rounded poles. Wall rather heavy, with a small internal thickening at the poles; a ring of pores just above and below the isthmus, and sparsely scattered pores elsewhere, each pore with a small pimple („pore-organ") on the inner surface of the wall as seen in optical section. Chloroplast and pyrenoids unknown because only empty specimens were seen. Vertical view circular. L 36—39; W 12—13; I about 12. Hab. Sumatra 114.

*Cosmarium perfissum* G. S. West (1908). Fa. Pl. 26, Fig. 8.
L 22; W 29; I 5; T 12. Hab. Sumatra 115.

This is of about the same size as West's Australian specimens, but differs in the lack of the minute apical depression in front view, and the absence of the small central protuberance in vertical view. In our examples the wall is seen to be pierced by numerous pores, and is distinctly thicker on the dorsal margin than on the ventral and at the lateral angles.

*Cosmarium phaseolus* Bréb. var. *omphalum* (Schaarschm.) Racib. (1889). Pl. 31, Fig. 17.
L 15; W 14; I 4. Hab. Borneo 38A.

*Cosmarium portianum* Arch. (1860). Pl. 28, Fig. 8.
L 20; W 18; I 6; T 12. Hab. Java M & P.

*Cosmarium portianum* Arch. var. *majus* var. nov. Pl. 28, Fig. 9.

Cellulae forma speciei similes, sed multo maiores. Varietas differt

necnon eo quod ordines non horizontales sed acclives sursum utroque a latere ad lineam mediam verticalem, angulum ca. 25° contra horizontalem formantes.

Shape of cells similar to that of the species; size much larger. Differs also in that the rows of granules are not horizontal but slope upward from each side towards the vertical centerline, forming an angle of about 25° with the horizontal.
L 58; W 45; I 18; T 29. Hab. Java 504.

*Cosmarium portianum* Arch. var. *nephroideum* Wittr. (1872). Fa. Pl. 28, Fig. 10.
L 30; W 25; I 9; T 16. Hab. Borneo 403.

*Cosmarium prominulum* Racib. (1885) var. *orientale* var. nov. Pl. 32, Fig. 22.

Varietas magnitudine formaque speciei similis. Differt eo quod apex magis applanatus, granulo eminente utrumque ad angulum apicalem praeditus; a latere visa differt possessione protuberantiarum centralium oblique truncatarum emarginatarum quae, a vertice etiam visae, multo prominentiores sunt.

Size and shape similar to those of the species. Differs in the more flattened apex with a projecting granule at each apical angle; in side view differs in the obliquely truncate and emarginate central protuberances, which also are much more prominent in the vertical view.
L 15; W 16; I 7; T 12. Hab. Sumatra 114.

*Cosmarium protuberans* Lund. (1871) var. *sumatranum* var. nov. Pl. 32, Fig. 18.

Varietas differens eo quod minor triente quam species. Semicellulae a fronte visae forma differentes quod margines laterales paululum retusi atque sursum convergentes, non divergentes tamquam in specie.

Dimensions about one-third less than those of the species. Shape of semicells in front view differs in that the lateral margins are slightly retuse and convergent upwards instead of divergent as in the species.
L 18; W 16; I 4.5, T 11. Hab. Sumatra 148.

*Cosmarium pseudoarctoum* Nordst. (1879). Pl. 32, Fig. 30.
L 14; W 11; I 9.5. Hab. Sumatra 114.

*Cosmarium pseudoconnatum* Nordst. (1870). Pl. 25, Fig. 4.
L 65—66; W 49—54; I 45—49. Hab. Java P; Sumatra 105.

*Cosmarium pseudoexiguum* Racib. (1885). Pl. 32, Fig. 8.
L 25; W 14; I 5. Hab. Sumatra 114.

*Cosmarium pseudoexiguum* Racib. var. *quadratum* Krieg. (1933). Pl. 32, Fig. 9.
L 19; W 11; I 3.5; T 6. Hab. Sumatra 114.

*Cosmarium pseudopyramidatum* Lund. var. *oculatum* Krieg. (1933). Pl. 27, Figs. 2, 3.
L 53—60; W 34—36; I 14. Zygospore L ssp 66, csp 81; W ssp 48, csp 60. Hab. Sumatra 114.

Our illustration shows the zygospore to be ellipsoidal while KRIEGER'S is globose, though the structure is the same. According to WEST & WEST (1905) the zygospore of the species is globose to ellipsoidal, but tuberculate instead of spiny.

*Cosmarium pseudotaxichondrum* Nordst. var. *siamense* West & West (1901) fa. *denticulatum* fa. nov. Pl. 31, Fig. 12.

*Cosmarium* magnitudine formaque var. *siamensi* simile; differens possessione granuli supraisthmalis atque quattuor dentium parvorum admodum infra marginem apicalem.

In size and shape similar to var. *siamense.* Differs in the possession of a supraisthmian granule, and four small teeth just below the apical margin. L 30; W 31; I 9; T 18. Hab. Java K.

*Cosmarium punctulatum* Bréb. var. *subpunctulatum* (Nordst.) Börges. (1894). Fa. Pl. 31, Fig. 8.
L 25; W 23; I 9; T 15. Hab. Sumatra 147.

*Cosmarium pyramidatum* Bréb. in Ralfs (1848). Pl. 27, Fig. 1.
L 69—83; W 39—41; I 16—21; T 30. Hab. Borneo 270.

*Cosmarium quadrifarium* Lund. (1871). Fa. Pl. 30, Fig. 10.
L 42; W 33; I 16; T 25. Hab. Borneo 38A.

*Cosmarium quadrifarium* Lund. var. *simplex* Krieg. (1933). Pl. 30, Fig. 11.
L 38; W 28; I 13. Hab. Borneo 38A; Sumatra 147, 148, 149.

*Cosmarium quadriverrucosum* West & West (1907) var. *undulatum* var. nov. Pl. 30, Fig. 7.

Varietas magnitudine quasi eadem ac species; differens aspectu semicellularum magis depresso ob apicem truncatum; margines laterales apicalesque undulati.

Size about the same as that of the species. Differs in the more depressed appearance of the semicells because of the truncate apex; lateral and apical margins undulate. L 22—23; W 21—23; I 6—7; T 13—14. Hab. Sumatra 108, 115, 148.

*Cosmarium regnellii* Wille (1884). Fa. Pl. 23, Fig. 12.
L 22; W 19; I 6; T 13. Hab. Borneo 403.

*Cosmarium regnellii* Wille fa. *catenata* Krieg. (1933). Pl. 32, Fig. 13.
L 16; W 16; I 4. Hab. Sumatra 114.

Several specimens of this catenate form were observed, the longest filament containing 14 cells. The cells are not in contact, but are separated by a layer of mucus about 1 μ thick. In one specimen the end cell had an attached „stalk" or „pedicel", transparent, colorless, 2-striate, enlarged at the distal end which adhered lightly to the glass slide during examination and required a small force to dislodge it.

*Cosmarium regnellii* Wille var. *chondrophorum* Skuja (1949). Pl. 32, Fig. 14.
L 14; W 12; I 4; T 10. Hab. Sumatra 148.

Skuja gives no dimensions for his variety, but says „*ceterum ut in typo*", leaving it to be inferred that the size is the same as in the species. If so, our plant is considerably smaller.

*Cosmarium regnesii* Reinsch (1867). Pl. 32, Fig. 23.
L 6.5—9; W 6—10; I 3.5—4.5; T 4—6. Hab. Sumatra 114, 148.

*Cosmarium regnesii* Reinsch var. *productum* West & West (1902). Pl. 32, Fig. 24.
L spr 10, cpr 15; W cpr 15; I 4.5; T 7.5. Hab. Sumatra 148.

Nordstedt (Index Suppl. 1908, p. 109) noted the resemblance of this plant to a biradiate *Staurastrum*, and suggested a comparison with *St. inconspicuum*. We have seen var. *productum* from U.S.A., the Sudan, and now from Sumatra, but have seen no evidence that would tend to connect it with any *Staurastrum*, though *St. inconspicuum* occurs in the Sumatra collection No. 148. Our present opinion, therefore, is that in spite of its curious shape the plant is properly assigned to *Cosmarium regnesii*.

*Cosmarium retusiforme* (Wille) Gutw. (1890). Fa. Pl. 32, Fig. 15.
L 24; W 19; I 6; T 12. Hab. Java 505.

*Cosmarium scabrum* Turn. (1892). Pl. 29, Fig. 3.
L 50; W 52; I 15; T 24. Hab. Sumatra 148.

This plant looks very much like and is probably identical with the one identified as *Cosmarium pardalis* Cohn by West & West in their Ceylon paper (1902, p. 170, Pl. 21, Fig. 2), and which they thought to be the same as *C. scabrum* Turn. However, both our plant and the Cingalese one differ considerably from the real *C. pardalis*, of which the senior author has seen actual specimens from

WITTROCK & NORDTSEDT'S Exsiccatae No. 559. In this dried material there are two different forms of the plant, corresponding to COHN'S Figs. 8a and 8b on Pl. XI (1879), of which Fig. 8b is of similar shape to the plant now under discussion. But the granulation of both forms is quite different from ours and from WEST & WEST'S; there are 8 or 9 rows each with about 20 to 22 granules; the granules are smaller and seem to be *solid*, each surrounded by 6 pores. Furthermore, the rows are horizontal or only slightly convex upwards (in the upper semicell), and they are alternating or decussate so that the granules do not form vertical rows. In other words, COHN'S illustrations give a reasonably correct idea of the plant, but he did not show enough rows of granules nor enough granules in each row. For comparison we give new illustrations of the two forms of *C. pardalis* in COHN'S material, on our Pl. 29, Figs. 1, 2.

Other authors have followed WEST & WEST in their interpretation of *C. pardalis*, so all such plants as correspond with their illustration and with ours must now be referred to *C. scabrum* Turn.

*C. pseudobroomei* Wolle is of similar size and shape to our plant, but the granules are solid, and there are no pores between the granules.

*Cosmarium sexangulare* Lund. (1871). Fa. Pl. 32, Fig. 10.
L 22; W 16; I 6. Hab. Borneo A.

*Cosmarium sexangulare* Lund. fa. *minimum* Nordst. (1887). Pl. 32, Fig. 11.
L 15—17; W 13—14; I 4—5; T about 8. Hab. Sumatra 147, 148.

*Cosmarium sinostegos* Schaarschm. (1882). Fa. Pl. 32, Fig. 19.
L 8; W ssp 10, csp 12; I 3; T 8. Hab. Sumatra 149.

Our illustration agrees with SCHAARSCHMIDT'S original illustration of the species, except that in the Sumatran plants the facial protuberance is in the supraisthmian position instead of central, and is emarginate in vertical view instead of sharply conical. We have seen only one specimen, so are not sure whether these characters are constant.

*Cosmarium sinostegos* Schaarschm. var. *obtusius* Gutw. (1892). Pl. 32, Fig. 20.
L 6.5; W 6.5; I 2.5; T 5. Hab. Sumatra 115. Smaller than any other record that we can find.

*Cosmarium spinuliferum* West & West (1902). Pl. 29, Figs. 6, 7.
L 32—34; W 33—35; I 10—11; T 20—21. Hab. Sumatra 108, 148.

*Cosmarium spyridion* West & West (1895). Pl. 31, Fig. 13.
L 13; W 13; I 5; T 10. Hab. Sumatra 148.

*Cosmarium staurastroides* Eichl. & Gutw. (1894) var. *porosum* var. nov. Pl. 32, Fig. 28.

Varietas forma cellulae speciei similis sed paululo maior; differens membrana brunnea ac porosissima, protuberantia centrali poris maioribus praedita.

Shape of cell similar to that of the species, size a little larger. Differs in the brown coloration of the wall which is strongly porose, with larger pores on the central protuberance. L 11—13; W 10.5—11; I 6.5—7; T 8. Hab. Sumatra 110, 114.

*Cosmarium striolatum* Näg. (1849). Pl. 25, Figs. 2, 3.
L 94—120; W 52—64; I 42—49. Hab. Borneo 401, 402; Sumatra 108, 147.

*Cosmarium strongylon* sp. nov. Pl. 32, Fig. 29.

Cellulae parvae, paululo longiores quam latae, isthmo lato, sinu late aperto; anguli basales ad margines laterales late rotundati; margines laterales ad angulos apicales, granulo eminente semicirculari parvo praeditos, paululum convergentes; apex convexus. Semicellulae a latere visae fere sphericae, granulis apicalibus sub apice visibilibus; a vertice visae latissime ellipticae, granulis apicalibus admodum intra polos visibilibus. Membrana laevis, sine colore.

Cells small, a little longer than wide, sinus widely open; basal angles widely rounded to the lateral margins which converge slightly to the apical angles which are provided with a small semicircular projecting granule; apex convex. In side view semicells nearly spherical, with the apical granules showing subapically. In vertical view very widely elliptical with the apical granules showing just within the poles. Wall smooth, colorless. L 16; W 13; I 8; T 11. Hab. Sumatra 114.

*Cosmarium subauriculatum* West & West var. *truncatum* West & West (1901). Pl. 26, Fig. 5. Syn. *C. suberosum* Schm. (1902).
L 42—44; W 47—51; I 22—23; T 26. Hab. Borneo K; Sumatra 108, 114, 147.

*Cosmarium subretusiforme* West & West (1894) var. *crassum* var. nov. Pl. 32, Fig. 16.

Cellulae minutae sed maiores ca. dimidio quam in specie. Cellulae a fronte latereque visae similes speciei, a vertice visae differentes quod late ellipticae, polis rotundatis, non anguste ellipticae, polis acutis.

Cells minute, but about one-half larger than the species. Front and side views similar to those of the species; vertical view differs in being broadly elliptical with rounded poles, instead of narrowly elliptical wit sub-acute poles. L 11.5; W 9; I 6.5; T 7. Hab. Sumatra 114; Java M & P.

Compare with *C. subretusiforme* in GRÖNBLAD, PROWSE & SCOTT (1957, Fig. 134) and see remarks on p. 33.

*Cosmarium tagmasterion* sp. nov. Pl. 29, Fig. 5.

Cellulae mediocres, paululo latiores quam longae, a fronte visa fere circulares; isthmus modice latus, sinus ad extremitatem interiorem angustus rectusque, deinde aperiens atque denuo ad extremitatem exteriorem per angulos basales deorsum eminentes, par granulorum hemisphericorum subflavorum ferentes, partim clausus; margines laterales apicalesque unum arcum continuum semiellipticum formantes, cuius partes laterales 8 vel 9 granula parva eminentia,versus angulos basales progredienter maiora ferunt. Centrum superficiei incrassatione magna flava, ornatum elaboratum granulorum rotundatorum non altorum habente, praeditum, unoquoque granulo sex lacunis triangularibus in hexagonis ordinatis circumdato. Semicellulae a latere visae subcirculares, marginibus lateralibus proiectiones circulares non altas praebentibus; series duplex granulorum parvorum a loco infra apicem ad angulos basales duplicia granula ferentes extensorum. Semicellulae a vertice visae oblongae, extremitatibus in terminationem obtusam emarginatum productis, marginibus lateralibus 7—8 undulationes parvas habentibus, utroque in latere intra marginem nonnulla parva lacunis interspersa, atque seriem duplicem granulorum ad lineam mediam longiorem parallelam praebentes; pars centralis membranae valde incrassata.

Cells of medium size, slightly wider than long, nearly circular in front view; isthmus moderately wide, sinus narrow and straight at inner end, then opening and again partly closed at the outer end by the downwardly protruding basal angles which bear a pair of yellowish hemispherical granules; lateral and apical margins forming one continuous semi-elliptical curve, the lateral portions of which bear 8 or 9 small projecting granules which become larger towards the basal angles. In the center of the face a large yellow incrassation with an elaborate ornament of low rounded granules each surrounded by six triangular pits arranged in hexagons. In side view semicells subcircular, the lateral margins with low circular projections; a double series of small granules extending from below the apex to the basal angles which bear twinned granules. In vertical view oblong with ends produced to a blunt emarginate termination, and lateral margins with 7 or 8 slight undulations; intramarginally on each side a

number of small granules interspersed with pits, and a double series of granules parallel with the longer centerline; central portion of the wall greatly thickened. L 53—57; W 55—60; I 18—20; T 30. Hab. Borneo X.

In shape this plant is quite like *C. nudum* and some forms of *C. taxichondrum*, but these species do not have the beautiful ornamentation. Compare *Arthrodesmus heimii* Bourr. (1957), = *A. stellifer* Grönblad & Scott (1958).

*Cosmarium tinctum* Ralfs (1848) fa. *tortum* fa. nov. Pl. 32, Fig. 26.

Cellulae minutae, aeque longae ac latae, modice constrictae; semicellulae ellipticae, margine apicali paululum retuso. Semicellulae a vertice visae ellipticae, ad isthmum per angulum 90° tortae; a latere visae subcirculares. Membrana levis, sine colore.

Cells minute, width and length about equal, moderately constricted; semicells elliptical with the apical margin slightly retuse. Vertical view elliptical, and showing the semicells to be twisted at the isthmus through an angle of 90°. Side view of cells subcircular. Wall smooth, colorless. L 10; W 10; I 6.5; T 9. Hab. Sumatra 114.

This twisted form has also been found in the Sudan; Cf. GRÖNBLAD, PROWSE & SCOTT 1958, p. 34, Figs. 138, 139.

*Cosmarium tinctum* Ralfs var. *tumidum* Borge (1903). Pl. 32, Fig. 27.
L 8.5—9.5; W 8—9.5; I 4.5—5; T about 5.5. Hab. Sumatra 114.

Our specimens are considerably smaller than those of BORGE from Brazil, but otherwise in good agreement. The wall is yellowish to brown, faintly punctate, and the margins are smooth. There is some resemblance to *C. emarginatum* West & West, but in that plant the wall is smooth and there is no mention of color in the description.

*Cosmarium tjibenongense* Gutw. fa. *minus* G. S. West (1909). Pl. 27, Fig. 8.
L 33; W 21; I 6; T 15. Hab. Sumatra 114, 148.

Compare with *C. aversum* var. *sumatranum* nob., from Sumatra 111.

*Cosmarium trachypleurum* Lund. var. *nordstedtii* Gutw. (1902). Pl. 31, Fig. 6.
L 36; W 31; I 10; T 21. Hab. Sumatra 103.

*Cosmarium trachypolum* West & West (1897). Pl. 26, Fig. 14.
L 28; W 15—16; I 14—15. Hab. Sumatra 107, 114, 148.

*Cosmarium tumidum* Lund. (1871). Pl. 27, Fig. 16.
L 32; W 26; I 7. Hab. Sumatra 114.

*Cosmarium vitiosum* Scott & Grönbl. (1957) var. *orientale* var. nov. Pl. 31, Figs. 1, 2.

Varietas magnitudine quasi eadem ac species. Differt quod dentes marginales prominentiores atque quattuor verrucas subapicales habet. Differt necnon numero ordinationeque granulorum pororumque ornatus centralis.

Size about the same as that of the species. Differs in the more prominent marginal teeth, the number (4) of subapical verrucae, and the number and arrangement of the granules and pores of the central ornament. L 39—42; W 33—39; I 10—12; T 20—23. Zygospore, diam. spr 39, cpr 54. Hab. Java M & P; Sumatra 103, 114, 115, 147.

As was the case with the U.S.A. specimens, there is some variation in the arrangement of the central ornament.

*Cosmarium westii* Bern. (1908). Pl. 26, Fig. 12.
L 45—63; W 32—39; I 30—36. Hab. Borneo A; Java 505.

The smaller set of dimensions is for the Java specimens; the larger set for those from Borneo. There are two pyrenoids in each semicell.

*Cosmarium zonatum* Lund. (1871). Pl. 28, Fig. 5.
L 48; W 25; I 10. Hab. Sumatra 147.

*Cosmarium zonatum* Lund. var. *pyriforme* var. nov. Pl. 28, Figs. 6, 7.

Varietas differens forma semicellularum pyriformi, marginibus inferioribus lateralibus aliquantulum retusis, ad isthmum abrupte constrictis; sinus V-formis, extremitate interna rotundata. Semicellula a vertice visa circularis. Quattuor anuli pororum magnorum, membrana inter poros delicate punctata, visi.

Differs in the pear-like shape of the semicells, with lower lateral margins somewhat retuse, sharply constricted at the isthmus; sinus V-shaped with rounded inner end. Four rings of large pores, and wall delicately punctate between the pores, Vertical view circular. L 54—59; W 25; I 7—9. Hab. Sumatra 114.

This should be compared with *C. pyriforme* Nordst. (1870) which is of similar size and shape in front view, but is decidedly elliptical in vertical view, and does not have the rings of large pores.

## Arthrodesmus Ehrenberg 1838

*Arthrodesmus apiculatus* Josh. (1886). Pl. 34, Fig. 11.
L 36—39; W 37—38; I 10; T 21. Hab. Sumatra 105.

*Arthrodesmus arcuatus* Josh. (1886). Pl. 35, Fig. 1.
L ssp 42, csp 57; W ssp 36, csp 57; I 9; T 24. Hab. Borneo 213.

*Arthrodesmus arcuatus* Josh. var. *incrassatus* var. nov. Pl. 35, Fig. 2.

Varietas magnitudine formaque speciei similis; differt possessione maculae refractivae aureo-brunnae admodum super centrum semicellulae, a latere verticeque visae velut incrassationis internae observatae. Membrana sparse porosa nisi intra regionem incrassatam. Semicellulis duobus pyrenoideis praedita.

Size and shape as in the species. Differs in the possession of a golden-brown refractive spot just above the center of the semicell, which is seen to be an internal incrassation in side and vertical views. Wall sparsely porose except within the thickened area. Two pyrenoids per semicell.

L ssp 35—39, csp 43—52; W ssp 33—38; csp 64—67; I 10—13; T 23. Hab. Borneo 134; Sumatra 102, 108.

This plant is identical with the one described as a *forma* of *A. arcuatus* in our Arnhem Land paper (1958). Since then we have seen the specific form which does not have the incrassation.

*Arthrodesmus arcuatus* Josh. (1886) var. *minus* var. nov. Pl. 35, Fig. 3.

Varietas forma speciei similis, differens eo quod apex minus convexus atque cellula aliquanto minor; quodque semicellula unicum pyrenoideum habet, specie atque var. *incrassato* duo habente.

Similar in shape to the species, but with a less convex apex, and considerably smaller. Also it has only one pyrenoid per semicell, while the species and var. *incrassatus* have two. L ssp 26, csp 42; W ssp 24, csp 46; I 6; T 15. Hab. Sumatra 148.

*Arthrodesmus bifidus* Bréb. (1856). Fa. Pl. 35, Fig. 13.

L to depressed apex 11, csp 18; W csp 17; I 7. Hab. Java 501.

Somewhat different from the U.S.A. form and larger than the species; semicells slightly twisted at the isthmus. Compare Bourrelly & Manguin (1946), Pl. 9.

*Arthrodesmus constrictus* G. M. Smith (1922) var. *longispinus* Grönbl. (1945). Pl. 36, Fig. 2.

L 25—30; W ssp 20—25, csp 57—68; I 5; T 10. Hab. Borneo 134, 206—212, 108—135—146.

*Arthrodesmus convergens* Ehrbg. (1838). Pl. 34, Figs. 7—10.

L 30—35; W ssp 36—40, csp 57—69; I 10—11: T 18. Hab. Java 501A, 502; Sumatra 102, 108.

*Arthrodesmus convergens* Ehrbg. var. *curtus* Turn. (1892). Pl. 34 Figs. 5, 6.

L 54—60, W ssp 51—57, csp 70—81; I 15—18; T 30—32. Hab. Java 501A, 505.

Although considerably larger than TURNER's dimensions this corresponds very well with his illustration, particularly as regards the short and slender spines. Compare *A. convergens* fa. SCOTT & GRÖNBLAD (1957) Pl. 13, Fig. 12.

*Arthrodesmus crassus* West & West (1903). Fa. Pl. 35, Fig. 8.
L 28; W 28; I 10; T 13. Hab. Sumatra 114.

*Arthrodesmus curvatus* Turn. (1982) var. *borgei* var. nov. Pl. 34, Figs. 2, 3.

Cellulae parvae, multo minores quam in specie, profunde constrictae, sinu late aperto; margines ventrales in acru circulari ad angulos superiores-laterales, spinam longam fere horizontalem ferentes, curvati; margo apicalis planus aut vix convexus. Cellulae a vertice visae anguste ellipticae, polis in spinas longas rectas productis. Semicellula uno pyrenoidea praedita.

Cells small, much smaller than the species, deeply constricted, sinus widely open; ventral margins curved in a circular arc to the upper lateral angles which bear a long and nearly horizontal spine; apical margin flat or only slightly convex. In vertical view narrowly elliptic, the poles prolonged into long straight spines. One pyrenoid per semicell. L 24—30; W ssp 24—32, csp 64—68; I 7—8. Hab. Borneo 134; Sumatra 148.

This agrees with an illustration by BORGE (1928) Pl. 2, Fig. 27, of a plant from East Africa, which he said was a straight-backed form of *A. curvatus*. It differs so much from the type that it is well worthy of a varietal name.

*Arthrodesmus curvatus* Turn. var. *incrassatus* Scott & Presc. (1958). Pl. 34, Fig. 4.
L 32; W ssp 30, csp 52; I 9; T 19. Hab. Sumatra 108.

*Arthrodesmus curvatus* Turn. var. *kalimantanus* var. nov. Pl. 34, Fig. 1.

Cellulae multo maiores quam in specie atque in fa. *maiore* Turn., profunde constrictae, sinus in parte interna inapertus linearisque, externe apertus; margines ventrales semicellularum ad angulos superiores-laterales spinas perlongas crassasque ferentes, late curvati; spinae ad extremitatem proximalem fere rectas, deinde abrupte curvatae atque convergentes, ad extremitatem distalem paululum recurvatae; margo apicalis paululum ac aeque donvexus. Cellulae a vertice visae ellipticae, polis in spinas longas crassas subcurvatas, at latere lineae mediae deflexas, productis. Chloroplastus furcatus; semicellula uno pyrenoideo praedita.

Cells much larger than the species and than fa. *major* Turn., deeply constricted, inner portion of sinus closed and linear, open exteriorly; ventral margins of semicells broadly curved to the upper lateral angles which bear very long and stout spines; spines nearly straight at the proximal end, then quickly curved and convergent and slightly recurved at the distal end; apical margin slightly and uniformly convex. In vertical view elliptical, the poles extended into long, stout, slightly curved spines which are deflected to alternate sides of the centerline. Chloroplast furcate, with one pyrenoid per semicell. L 53—57; W ssp 57—63, csp 108—117; I 18—21; T 29—32. Hab. Borneo 403.

This variety shows a considerable resemblance to the American *A. maximus* var. *ecplecticus* Scott & Grönbl. (1957), but differs in having only one pyrenoid per semicell, while all the forms of *A. maximus* have two. Until more is known about the significance of the number of pyrenoids it seems preferable to assign this form to *A. curvatus*, which has only one pyrenoid.

*Arthrodesmus curvatus* Turn. var. *latus* var. nov. Pl. 33, Figs. 1—3.

Varietas maior atque multo latior quam species, et cum et sine spinis. Chloroplastus furcatus; semicellula uno pyrenoideo praedita.

Larger and much wider than the species, both with and without spines. Chloroplast furcate with one pyrenoid per semicell. L 42—57; W ssp 44—45, csp 91—109; I 12—16; T 20—23. Hab. Borneo X; Java P, M & P; Sumatra 147.

*Arthrodesmus curvatus* Turn. var. *latus* nob. Formae cum spinis supernumeriis. Pl. 33, Figs. 4—8.

We illustrate some curious forms in which one or both semicells possess an extra spine at one or both upper angles. Fig. 8 shows a very peculiar form consisting of four attached semicells, two of which have extra spines. When this specimen was first seen it was thought to be two cells in the first stage of conjugation, but apparently this was not the case. Despite efforts lasting several hours it proved impossible to draw the side view because of the unequal length of the spines, and it was even impossible to balance it long enough to get a good look at the side view, nor to see the isthmus in any position because of the dense chloroplast. The side view in Fig. 8 is therefore „constructed", and the method of attachment of the four semicells at the isthmus is more or less conjectural. No explanation can be offered for the presence of the extra spines, and all these forms must for the present be classed simply as abnormalities.

*Arthrodesmus gibberulus* Josh. (1885). Pl. 35, Fig. 6.
L 39; W csp 49; I 12; T 24. Hab. Borneo 403.

*Arthrodesmus gibberulus* Josh. (1885). Fa. Pl. 35, Fig. 7.
L 35; W ssp 30, csp 45; I 9; T 21. Hab. Borneo X; Sumatra 148.

A form with more slender spines and with a prominent yellow lenticular incrassation.

*Arthrodesmus incus* (Bréb.) Hass. var. *extensus* Anderss. (1890). Pl. 36, Fig. 1.
L to depressed apex 23, csp 33; W ssp 24, csp 39; I 7. Hab. Sumatra 109.

*Arthrodesmus menoides* sp. nov. Pl. 36, Fig. 7.

Cellulae parvae, paululo latiores quam longae, profundissime constrictae, sinu late aperto. Semicellulae crescenticae, margine apicali profunde concavo, angulis apicalibus spine brevi aut dente praeditis. Membrana tenuissima delicatissimaque. Semicellulae ad isthmum paululum tortae; a vertice visae anguste ellipticae, spina brevi utrumque ad polum praeditae.

Cells small, a little wider than long, very deeply constricted, sinus widely open. Semicells crescentic, apical margin deeply concave, apical angles provided with a short spine or tooth. Wall very thin and delicate. Semicells slightly twisted at the isthmus. Vertical view narrowly elliptical with a short spine at each pole. L to depressed apex 18, csp 28; W max 31; I 6; T 9—10. Hab. Sumatra 108.

*Arthrodesmus octocornis* Ehrbg. (1838). Pl. 35, Figs. 9—12.
L to depressed apex 10—17, csp 22—39; W ssp 11—12, csp 22—30; I 3.5—4.5. Hab. Borneo 206—212; Sumatra 107, 115, 148, 149.

An unusual form from Sumatra 107 is shown in Fig. 10, in which the lower spines of the two semicells are so convergent that they overlap slightly at their tips.

*Arthrodesmus psilosporus* (Nordst. & Löfg.) De Toni (1889). Formae. Pl. 36, Figs. 5, 6. Syn. *Staurastrum psilosporus* Nordst. & Löfg. (1883) in Wittr. & Nordst. Alg. Exsicc. No. 558.
L 27—28; W max. 24—27; I 9; T 11—12. Hab. Sumatra 110.

The only two specimens that we have seen are shown in our two figures. They differ considerably from the type, of which we have seen specimens on a slide prepared by Dr. Hannah Croasdale from Wittrock & Nordstedt's Exsiccatae No. 558, and of which we give a figure for comparison. *Straurastrum blandum* Racib. (1884, Pl. 1, Fig. 19) is not unlike *A. psilosporus* and may perhaps be identical with it.

*Arthrodesmus sachlanii* sp. nov. Pl. 34, Fig. 12.

Cellulae magnae, paululo longiores quam latae (cum spinis),

profunde constrictae, sinus intus late apertus, extra, autem, per angulos basales semicellularum deorsum fere clausus. Semicellulae subrectangulares, marginibus lateralibus profunde concavis, margine apicali plano, utroque angulo superiore-lateri duabus spinis perlongis crassis subcurvatis divergentibus, e basibus conicis cavis magnis enascentibus, praedito. Centrum superficiei inflatione circulari parva probabiliter praeditum. Cellulae a latere verticeque non visae. Semicellula uno pyrenoideo praedita.

Cells large, slightly longer than wide (with spines), deeply constricted, sinus widely open within but nearly closed at the exterior by the downwardly projecting basal angles of the semicells. Semicells subrectangular, lateral margins deeply concave, apical margin flat, upper lateral angles each provided with two very long, stout, slightly curved, divergent spines which arise from large, hollow, conical bases. Probably a small circular swelling in the center of the face. Vertical and side views not obtained. One pyrenoid per semicell. L to depressed apex 42, csp 105; W ssp 40, csp 99; I 13. Hab. Sumatra 114.

Only one specimen has been seen of this plant, and despite lengthy efforts it was impossible to obtain the other views. However, it differs so greatly from all other known *Arthrodesmi* that we feel warranted in creating a new species, and we take pleasure in dedicating it to Mr. M. SACHLAN, who has devoted so much effort and care in making these Indonesian collections.

*Arthrodesmus spechtii* Scott & Presc. (1958). Pl. 35, Fig. 14.
L ssp 27, csp 44; W ssp 25, csp 30; I 7; T 15. Hab. Sumatra 115.

This is slightly larger than the Australian plant, otherwise in good agreement except that the spines are somewhat divergent instead of convergent, and in vertical and side views they are not deflected from the vertical plane.

*Arthrodesmus subvalidus* Grönbl. (1945). Pl. 35, Figs. 4, 5.
L ssp 25—31, csp 52—67; W ssp 27—33, csp 61—69; I 6—8; T 14—17. Hab. Sumatra 115, 148.

In Sumatra 115 this plant occurs with one and with two pyrenoids per semicell, but the two forms are otherwise indistinguishable.

*Arthrodesmus sumatranus* sp. nov. Pl. 36, Figs. 3, 4.

Cellulae parvae, ca. 1¼-plo longiores quam latae (cum spinis), modice constrictae, isthmo paululum elongato, indentationem minutam ad centrum interdum praebente; lobi laterales semifusiformes atque late divergentes, angulis superioribus in spinas longas tenuesque productis; margo apicalis profunde concavus. Semicellula a

vertice visa anguste elliptica, spinam longam utrumque ad polum habens, uno pyrenoideo praedita.

Cells small, about $1\frac{1}{4}$ times longer than wide (with spines), moderately constricted, isthmus somewhat elongated and sometimes showing a minute identation at the center, lateral lobes semifusiform and widely divergent, upper angles extended into long thin spines; apical margin deeply concave. Vertical view narrowly elliptical with a long spine at each pole. One pyrenoid per semicell. L to depressed apex 14, csp 36—39; W ssp 15—16, csp 31—35; I 6—7. Hab. Sumatra 114, 149.

In the literature can be found illustrations of plants, not unlike this one, which have been referred to *A. incus*. However, none of them is identical, and we feel disinclined to make further additions to the *incus* complex, which contains several forms that we think are not closely related.

## XANTHIDIUM Ehrenberg 1837

*Xanthidium acanthophorum* Nordst. var. *raciborskii* Gutw. (1902). Pl. 36, Fig. 12. Pl. 37, Fig. 1.
L ssp 41—42, csp 53—54; W ssp 39, csp 48; I 15; T 20—23.
With supraisthmian granule; Java T, Sumatra 103, 114.
Without supraisthmian granule; Borneo X; Java 505; Sumatra 147, 148.

There is remarkably little variation in size among specimens from all these widely separated localities. In some examples the facial pits are circular; in others, probably older ones, they are triangular; and as noted there are supraisthmian granules in some specimens. GUTWINSKI's original description mentions four transverse rows of pits, and his illustration shows this, but we believe it to be a mistake. Careful examination shows that the central mark in each hexagonal group is a small raised granule, and it is proved by the small protuberances seen in vertical and side views.

*Xanthidium antilopaeum* (Bréb.) Kutz. fa. *javanicum* Nordst. (1880). Pl. 38, Fig. 1.
L ssp 57—66, csp 105—120; W ssp 58—69, csp 129—144; I 25—30; T 39. Hab. Borneo X, 401.

*Xanthidium antilopaeum* (Bréb.) Kütz. var. *laeve* Schm. (1893) fa. *longispinum* fa. nov. Pl. 38, Fig. 2.

Spinae multo longiores quam in typo; sinus vere clausus.

Spines much longer than in the type; sinus closed instead of open. L ssp 84, csp 141; W ssp 62—69, csp 117—129; I 21—22; T 42. Hab. Sumatra 148.

This is the same plant that we listed and illustrated (1958) from N. Australia as *X. antilopaeum* fa.

*Xanthidium antilopaeum* (Bréb.) Kütz. var. *laeve* Schm. (1893) fa. *minus* fa. nov. Pl. 38, Fig. 3.

Forma minor formae *longispini* supra depictae; minor triente quam var. *laeve*, spinis longioribus, sinu inaperto.

A smaller form of the preceding fa. *longispinum*; about two-thirds the size of var. *laeve*, with longer spines, and with closed sinus. L ssp 48, csp 72; W ssp 42, csp 84; I 14; T 24. Hab. Sumatra 103.

*Xanthidium armatum* (Bréb.) Rab. var. *anguligerum* Krieg. (1933). Formae. Pl. 39, Figs. 4, 5.
L spr 96—101, cpr 117—127; W cpr 93—98; I 28; T cpr 73. Hab. Borneo 38; Sumatra 112, 115.

*Xanthidium burkillii* West & West (1907). Pl. 40, Fig. 1.
L ssp 45, csp 67; W ssp 51—54, csp 76—84; I 22—27; T 22—29. Hab. Borneo 403; Java K.

*Xanthidium burkillii* West & West var. *alternans* Skuja (1949). Pl. 40, Fig. 2.
L ssp 45, csp 81; W ssp 45—48, csp 87—94; I 22—23; T 27. Hab. Borneo X.

Comment by SCOTT: My friend Lektor EINAR TEILING and I have had some correspondence regarding this plant, of which I sent him a drawing for his paper on Asymmetry in Desmids (1957). He thinks that my illustration does not depict SKUJA's variety, and bases this opinion upon a statement that Prof. SKUJA made to him that the illustration of the vertical view (SKUJA 1949, Pl. 33, Fig. 16a) is not quite correctly drawn. TEILING thereupon drew a modified version of the vertical view as he thought it ought to appear, and submitted it to SKUJA who pronounced it more nearly correct, though whether or not he compared it with actual specimens I do not know. TEILING (1957, p. 74) states that „the subapical spines a and c and the apical spines b and d are lacking"; in other words he thinks that the three spines on each side are all lateral ones. This is a matter of opinion; in my view the two uppermost spines in SKUJA's front view and in mine are properly called apical spines, and they are placed on alternate sides of the centerline, whence the name *alternans*. In SKUJA's description he states that the row of pits on each side of the isthmus was missing; in the Borneo specimens the pits are usually clearly visible in a yellow band above and below the isthmus, and as this is

an unusual feature in *Xanthidium* I consider it as a proof that the plant is correctly assigned to *X. burkillii*.

BOURRELLY (1957, Pl. 11, Fig. 101) illustrates *X. pseudobengalicum* var. *basiornatum* var. nov., which appears to be identical with our illustration of *X. burkillii* var. *alternans*. We think BOURRELLY'S plant was incorrectly assigned to *X. pseudobengalicum* because the shape of the semicell and the position of the spines differ greatly from those of GRÖNBLAD'S illustration of the species (1921, Pl. 4, Figs. 32—33).

*Xanthidium calcarato-aculeatum* (Hier.) Schm. (1898). Pl. 39, Fig. 3.
L ssp 54—60, csp 80—87; W ssp 51—58, csp 66—75; I 14—15; T 41. Hab. Sumatra 112.

In a later paper (1902) SCHMIDLE stated that he thought this plant should be placed as a variety of *X. trilobum* Nordst. Apparently NORDSTEDT himself did not agree with this (Cf. NORDSTEDT'S Inde x Suppl., 1908, p. 36). We also think there are enough differences between the two plants to warrant a separate species.

*Xanthidium freemanii* West & West (1902). Fa. Pl. 37, Fig. 4.
L ssp 95, csp 102; W ssp 84, csp 96; I 45. Hab. Borneo M & P.

Only one specimen was seen, and like WEST & WEST we were unable to obtain the other views. The Borneo plants are somewhat larger than those from Ceylon; they have one marginal and one intramarginal row of eight spines, and a second intramarginal row of five or six. The lateral margins are slightly undulate, with one spine arising from each crest of the undulations.

*Xanthidium hastiferum* Turn. (1892). Pl. 40, Figs 3, 4.
L ssp 36—40, csp 52—73; W ssp 28—42, csp 66—85; I 9—12; T 21. Hab. Borneo 38, 108—135—146.

In a few specimens instead of the four apical spines there were only two, placed on opposite sides of the centerline in vertical view.

*Xanthidium hastiferum* Turn. var. *javanicum* (Nordst.) Turn. fa. *planum* Turn. (1892). Pl. 40, Fig. 5.
L ssp 37—44, csp 60—69; W ssp 39—48, csp 69—94; I 11—12, T18. Hab. Java 502; Sumatra 102, 148.

*Xanthidium horridum* Skuja (1949) var. *decoratum* var. nov. Pl. 36, Fig. 11.

Varietas magnitudine formaque speciei similis; differens eo quod spinae in centro superficiei (velut circuli a vertice visae) per sex lacunas triangulares ordinatas ut vulgo hexagonaliter circumdantur.

Size and shape as in the species; differs in that four spines in the center of the face (seen as circles in end view) are each surrounded by six triangular pits in the usual hexagonal arrangement. L ssp 55, csp 65; W ssp 54, csp 60; I 18; T ssp 30, csp 42. Hab. Borneo X, 402.

*Xanthidium kalimantanum* sp. nov. Pl. 40, Fig. 6.

Cellulae magnae, paululo longiores quam latae (sine spinis); modice constrictae, sinu V-formi apertoque. Semicellulae subelliptícae, apice paululum convexo, centro superficiei incrassationem internam magnam brunneam praebente; membrana conferte porosa. Semicellula 12 spinis longis crassis rectis aut paululum curvatis, ad basim tumidis, 6 spinis in superficie superiore, 6 in inferiore, praedita. Semicellula a vertice visa subhexagonalis, duas inflationes prominentes ac incrassationes internas praebens, ambobus brevissimis lateribus retusis, spinam longam rectam ad angulos habentibus, necnon 8 spinas intramarginales asymmetrice ordinatas habens.

Cells large, a little longer than wide (without spines); moderately constricted, sinus V-shaped and open. Semicells subelliptical, apex slightly convex; a large brown internal incrassation in the center of the face; wall closely porose. On each semicell 12 long, stout, straight or slightly curved spines with swollen bases, 6 on the upper and 6 on the lower surface. In vertical view subhexagonal, with two prominent swellings and internal thickenings, the two shortest sides retuse, and at their angles a long straight spine; intramarginally 8 other spines in an asymmetrical arrangement.
L ssp 57, csp 90—96; W ssp 48—52, csp 89—96; I 18; T 39. Hab. Borneo X, 43, 134, 108—135—146.

*Xanthidium lepidum* West & West (1902). Pl. 36, Figs. 8, 9.
L 46—48; W 36—40; I 10—11; T 22. Hab. Borneo X; Sumatra 114.

Our Fig. 9 shows a specimen from Sumatra 114 that is somewhat wider and more nearly circular in shape than the Ceylon plants.

*Xanthidium lepidum* West & West var. *reversum* var. nov. Pl. 36, Fig. 10.

Varietas magnitudine formaque speciei similis; differens eo quod plura granula facialia habet, quodque ambo hexagona lacunarum triangularium verticaliter non horizontaliter ordinantur.

Similar in size and shape to the species, but with more facial granules and with the two hexagons of triangular pits arranged one above the other instead of side by side.
L 42; W csp 36; I 12; T 23. Hab. Sumatra 103.

*Xanthidium perissacanthum* sp. nov. Pl. 41, Figs. 1, 2.

Cellulae magnae, ca. $1\frac{1}{4}$-plo longiores quam latae (sine spinis), profundius constrictae, sinu intus inaperto linearique, externe late aperto. Semicellulae oblongae, marginibus lateralibus late rotundatis, margine apicali brevi fere plano. Una series spinarum longarum rectarum aut paululum curvatarum admodum intra marginem in superficie semicellulae superiore, altera series in inferiore enascentes. Spinae numero variantes, vel 12 vel 14 utraque in semicellula: si 12 spinas, tres in superficie superiore, tres in inferiore utroque in latere semicellulae; si 14 spinae, quattuor in superficie superiore, tres in inferiore in latere sinistro semicellulae superioris, atque tres in superiore, quattuor in inferiore in latere dextro semicellulae superioris; quae dispositio asymmetricalis in semicellula inferiore inversa est. Semicellula a vertice visa subelliptica, polis truncatis ac paululum retusis a quorum angulo utroque spina longa enascitur; semicellula duas series intramarginales spinarum, vel quattuor vel quinque utroque in ordine, secundum numerum totum in semicellula habens. Chloroplastus in quattuor lobos quadrantales unoquoque aliquot pyrenoidea habente, divisus. Membrana conferte porosa.

Cells large, about $1\frac{1}{4}$ times longer than wide (without spines); rather deeply constricted; sinus closed and linear within, widely open to the exterior. Semicells oblong, with widely rounded lateral margins and a short, almost flat apical margin. One set of long, straight or slightly curved spines arising just within the margin on the upper surface of the semicell and another set on the under surface. Number of spines variable, either 12 or 14 on each semicell; when there are 12 spines there are three on the upper and three on the under surface on each side of the semicell; when the number is 14 there are four on the upper and three on the under surface on the left side of the upper semicell, with three on the upper and four on the under surface on the right side of the upper semicell; this asymmetrical arrangement is reversed in the lower semicell. Vertical view subelliptical with truncate and slightly retuse poles, from each angle of which arises a long spine; intramarginally two series of spines, with either four or five in each row depending on the total number on the semicell. Chloroplast in four quadrantal lobes, with several pyrenoids in each. Wall closely porose. L ssp 66—69, csp 114—124; W ssp 56—63, csp 103—117; I 17—18; T 36. Hab. Sumatra 149.

Many examples were seen, and the form with 14 spines seems to be more common than the one with 12 spines.

*Xanthidium perissacanthum* Scott & Presc. var. *minus* var. nov. Pl. 41, Fig. 3.

Varietas forma cellulae spinisque speciei similis, sed multo minor.

Semicellula decem spinis praedita, tribus in superficie superiore ac duabus in inferiore in latere sinistro semicellulae superioris, duobus in superficie superiore ac tribus in inferiore in latere dextro ordinatis; haec dispositio in semicellula inferiore reversa est. Chloroplastus et proprietates membranae ut in specie.

Shape of cell and spines similar to those of the species, size much smaller. Number of spines ten per semicell, arranged three on the upper surface and two on the under surface on the left side of the upper semicell, and two on the upper and three on the under surface on the right side; the arrangement being reserved in the lower semicell. Chloroplast and wall features as in the species. L ssp 54, csp 87; W ssp 48, csp 93; I 15; T 27. Hab. Sumatra 107.

So far only this one form with ten spines has been seen, but the asymmetrical arrangement of the spines is closely similar to that of the species.

*Xanthidium sansibarense* Hier. (1895, sub *Holacanthum*), Formae asymmetricae. Pl. 37, Figs. 6, 7.
L ssp 57—63, csp 88—99; W ssp 47—51, csp 94—100; I 17—18; T 28—31. Hab. Borneo X; Sumatra 105, 108.

Of a total of about 50 specimens seen, only two were of the specific form with all spines paired. Eight specimens had all the spines single. Of the remainder most had paired apical spines and single laterals.

*Xanthidium sexmamillatum* West & West var. *pulneyense* Iyengar & Bai (1941). Pl. 39, Fig. 2.
L ssp 50—53, csp 86—102; W ssp 45—57, csp 96—102; I 12—13; T 27. Hab. Sumatra 102, 112.

In these Sumatran specimens the length and width with spines are considerably greater than in the original Indian ones, because of the longer spines. The other features agree very well, including the central yellow incrassation and the two large pyrenoids.

*Xanthidium spinosum* (Josh.) West & West (1907). Fa. Pl. 37, Figs. 2, 3.
L ssp 48—51, csp 50—55; W ssp 49—53, csp 52—61; I 29; T 31. Hab. Sumatra 100, 108, 148.

Our specimens are closer to WEST & WEST'S *forma scrobiculata* than to the species, but not quite identical, particularly in the vertical view, which in ours is elliptical with narrowly rounded poles rather than broadly oval with widely rounded poles. The wall is sparsely porose and minutely punctate between the pores.

*Xanthidium subtrilobum* West & West (1897). Pl. 39, Fig. 1.

L ssp 54—59, csp 81—84; W ssp 48—54, csp 75—78; I 12—13; T 30. Hab. Borneo X; Java Z; Sumatra 104.

*Xanthidium subtrilobum* West & West var. *inornatum* Skuja (1949). Pl. 38, Figs. 4, 5.
L ssp 48—55, csp 70—77; W ssp 48—54, csp 70—78; I 12—13; T 28—36. Hab. Borneo X, 403.

The specific epithet was inadvertently spelled *subtrilobatum* in SKUJA's paper.

*Xanthidium superbum* Elfv. (1881). Pl. 37, Fig. 5.
L ssp 88, csp 114; W ssp 60, csp 89; I 19. Hab. Sumatra 108, 148.

## STAURASTRUM Meyen 1829

*Staurastrum acanthastrum* West & West (1902). Pl. 42, Fig. 1.
L 33; W cpr 75; I 9. Hab. Java T.

*Staurastrum acanthocephalum* Skuja (1949). Pl. 52, Figs. 5, 6.
L spr 21, cpr 36; W cpr 45—54; I 5—6; T 9. Hab. Borneo 134; Singapore 200.

Our specimens are less spiny than shown in SKUJA's illustration, otherwise in good agreement.

*Staurastrum anisacanthum* sp. nov. Pl. 56, Fig. 4.

Cellulae parvae, profundius constrictae, sinu late aperto. Semicellulae a fronte visae cyathiformes, marginibus ventralibus ad angulos superiores-laterales paululum convexis, qui anguli in processus longos tenues, tres dentes terminales ferentes, in marginibus ventralibus dorsalibusque minute denticulatos, producuntur; apex elevatus, coronam dentium minutorum ferens. Semicellulae a vertice visae triangulares, angulis productis in processus longos tenuesque, tribus dentibus terminalibus, marginibus undulatis ac duobus ordinibus intramarginalibus dentium minutorum praeditos; semicellulae habentes necnon ad basim uniuscuiusque processus duos processus minores, magnitudine inaeques, uno duas spinas parvae ferente, altero duas spinas parvas similes necnon tertiam spinam curvatam multo maiorem a margine laterali prominenter eminentem, ferente; semicellulae in centro apicis sex dentes parvos hexangulariter dispositos praebentes.

Cells small, rather deeply constricted, sinus widely open. In front view semicells cyathiform, ventral margins slightly convex to the upper lateral angles which are produced into long slender processes bearing three terminal teeth and minutely denticulate on their ventral

and dorsal margins; apex elevated and bearing a crown of minute teeth. In vertical view triangular, the angles produced into long slender processes with three terminal teeth, undulate margins, and two intramarginal rows of minute teeth; at the base of each process two smaller processes of unequal size, one bearing two small spines, the other with two similar small spines and a third much larger curved spine, projecting prominently from the lateral margin; in the center of the apex an hexagonal group of six small teeth. L 18—19; W cpr 42—50; I 6. Hab. Java 505; Sumatra 102, 107.

*Staurastrum anatinoides* Scott & Presc. (1958) var. *javanicum* var. nov. Pl. 56, Fig. 5.

Varietas magnitudine formaque cellularum speciei similis. Differt possessione anuli dentium parvorum acutorum admodum super infraque isthmum, ca. sex utroque in anulo visibilibus, differt necnon substitutione sex verrucarum emarginatarum per sex dentes apicales.

Size and shape of cells similar to those of the species. Differs in the possession of a ring of small sharp teeth just above and below the isthmus, about six visible in each ring, and in the replacement of the six apical teeth by six emarginate verrucae.
L 33; W cpr 50; I 10. Hab. Java 501A.

*Staurastrum arachne* Ralfs (1845) var. *sumatranum* var. nov. Pl. 59, Fig. 7.

Varietas magnitudine formaque speciei similis. Differt eo quod processus crassiores, atque dentes in marginibus dorsalibus processuum ac in superficie apicali prominentiores sunt.

Size and shape similar to those of the species. Differs in the stouter form of the processes and in the more prominent teeth on their dorsal margins and on the apical surface. L 23; W cpr 32—34; I 8. Hab. Sumatra 147, 148, 149.

*Staurastrum bifidum* Bréb. in Ralfs (1848). Pl. 54, Fig. 5.
L 32—37; W csp 43—57; I 12—15. Hab. Sumatra 108, 109.

*Staurastrum bigibbum* Skuja (1949). Pl. 53, Fig. 8.
L 16—17; W cpr 39—42; I 6—7. Hab. Borneo X, 134, 108—135—146.

*Staurastrum brachiatum* Ralfs (1848). Formae. Pl. 54, Fig. 12. Pl. 55, Fig. 10.
L spr 12, cpr 23; W cpr 25; I 5. (Smaller form)
14 · 38 40 8 (Larger form) Hab. Sumatra 114, 115.

This cosmopolitan species is rare in the Indonesian material, but appears in the two greatly differing forms that we illustrate.

*Staurastrum calyxoides* Wolle (1885) var. *orientale* var. nov. Pl. 55, Figs. 1, 2.

Varietas forma cellularum a fronte visarum speciei similis, longitudine cum spinis paululo maiore. A vertice visa differt eo quod margines inter spinas profunde concavi, non fere recti, sunt. In formis quinque- et sex-aculeatis reperta.

Shape of cells in front view similar to that of the species; length with spines somewhat greater. In vertical view differs in that the margins are deeply concave between the spines, instead of being almost straight. Occurs in both five- and six-spined forms. L ssp 30, csp 60—72; W ssp 27—30, csp 48—58; I 12—13. Hab. Sumatra 149.

*Staurastrum cerastes* Lund. var. *coronatum* Krieg. fa. *inflatum* Scott & Presc. (1958). Pl. 56, Fig. 6.
L 46; W base 13, cpr 59; I 10. Hab. Sumatra 148.

*Staurastrum cerastes* Lund. var. *pulchrum* Scott & Grönbl. (1957). Fa. Pl. 56, Fig. 7.
L 36; W cpr 65; I 7. Hab. Sumatra 148.

*Staurastrum ceylanicum* West & West (1902). Pl. 59, Fig. 1.
L 26; W cpr 35; I 9. Hab. Sumatra 108, 148.

*Staurastrum coarctatum* Bréb. var. *subcurtum* Nordst. (1887). Pl. 52. Fig. 15.
L 22—26; W 18; I 9. Hab. Sumatra 148.

*Staurastrum columbetoides* West & West (1902) var. *basiaculeatum* var. nov. Pl. 50, Figs. 1—3.

Varietas a fronte latereque visa magnitudine formaque speciei similis; differt possessione seriei dentium super infraque isthmum, dentibus semicellulae superioris, eis inferioris intermixtis. Semicellulae a vertice visae habentes corpus rhomboideum, processu longo tenui a unoquoque angulo acuto enascente praeditum. Corpus margines undulatos atque processum longum tenuemque admodum intra quemque angulum enascentem, habens; processus marginibus minute undulatis, ordine centrali dentium minutorum, atque extremitatibus furcatis praediti. Semicellulae a basi visae rhomboideae, margines undulatos atque ellipsem centralem (foramen isthmi) habentes; necnon admodum intra omnes quattuor angulos circulum (aspectum scilicet a polo dentis simplicis) habentes, necnon intra marginem in omnibus quattuor lateribus duo paria circulorum minorum (aspectum scilicet a polo duorum dentium bifidorum) habentes.

Size and shape in front and side views similar to those of the species; differs in the possession of a series of teeth above and below the isthmus, those of the upper semicell intermeshing with those of the lower one. In vertical view a rhomboidal body with undulate margins and with a long slender process arising just within each of the acute angles; processes with minutely undulate margins, a central row of minute teeth, and furcate ends. In basal view rhomboidal with undulate margins and a central ellipse representing the isthmian opening; just within the four angles a circle representing the end view of a simple tooth, and intramarginally on each of the four sides two pairs of smaller circles representing the end view of two bifid teeth. L spr 15—16; cpr 74—76; W spr 13, cpr 54—63; I 5.5 x 4.5; T 12—13. Hab. Borneo 134; Sumatra 114, 115, 148.

At first sight this plant looks very much like *St. ginzbergeri* Grönbl. (1945) from Brazil, which, however, has processes that are 2½ to 3 times as long as ours, and they are smooth, not serrate; further in the Brazilian plant all of the 8 basal verrucae are trifid, instead of being alternately simple and bifid as in the Indonesian. These differences were pointed out to us by Dr. Rolf Grönblad, who was kind enough to send us some specimens for examination.

*Staurastrum connatum* (Lund.) Roy & Biss. (1886). Pl. 53, Fig. 12.
L ssp 20, csp 33; W csp 25; I 6. Hab. Java 505.

*Staurastrum contectum* Turn. (1892). Fa. Pl. 54, Fig. 6.
L 27; W cpr 42; I 11. Hab. Sumatra 108, 148.

*Staurastrum corniculatum* Lund. var. *variabile* Nordst. (1887). Pl. 54, Figs. 1—4.
L ssp 27—30, csp 31—39; W ssp 27—35, csp 33—37: I 12. Hab. Java P; Sumatra 130, 148.

Both spined and spineless forms occur in the same collection, Sumatra 148.

*Staurastrum crenulatum* (Näg.) Delp. (1877). Fa. Pl. 59, Fig. 10.
L 23; W cpr 28; I 7.5. Hab. Sumatra 149.

*Staurastrum cryptoëdrum* Skuja (1949). Pl. 53, Figs. 1, 2.
L 16—19; W 14—15; I 12—13. Hab. Java 505; Sumatra 114, 148,

Pentagonal and hexagonal forms occur in collection Sumatra 114.

*Staurastrum curvatum* W. West. (1892). Pl. 41, Fig. 4.
L ssp 33, csp 60; W ssp 36, csp 81; I 10. Hab. Sumatra 110.

*Staurastrum curvatum* W. West. var. *cruciatum* Krieg. (1933). Pl. 53, Fig. 9.
L ssp 11, csp 18; W csp diag. 24; I 5. Hab. Sumatra 107.

*Staurastrum cuspidatum* Bréb. (1840). Pl. 53, Fig. 13.
L 22; W ssp 17, csp 35; I 4.5. Hab. Sumatra 114.

*Staurastrum cuspidatum* Bréb. var. *divergens* Nordst. (1870). Pl. 53, Fig. 15.
L ssp 22, csp 51; W ssp 25, csp 39; I 6. Hab. Sumatra 114.

*Staurastrum cuspidatum* Bréb. var. *divergens* Nordst. fa. *minus* fa. nov. Pl. 53, Fig. 16.

*Staurastrum* forma varieti simile, sed multo minus.

Similar in shape to the variety, but much smaller.

L ssp 16, csp 31; W ssp 15, csp 24; I 4. Hab. Sumatra 110.

*Staurastrum cuspidatum* Bréb. var. *incurvum* Heimerl. (1891). Pl. 53, Fig. 14.
L 21; W ssp 18, csp 23; I 4. Hab. Sumatra 103.

*Staurastrum cyclacanthum* West & West (1902) var. *armigerum* var. nov. Pl. 37, Figs. 1—3.

Varietas magnitudine formaque generali speciei similis, differens eo quod crassior, quodque longiores spinas prope extremitates distales, quodque a vertice visa maiores verrucas trifidas ad extremitates proximales processuum habet. Differt necnon a fronte visa eo quod duos vel tres dentes breves in margine ventrali semicellulae, vicem anuli granulorum basalium ut vulgo in specie, plerumque habet.

Size and general shape similar to those of the species. Differs in the stouter habit, in the larger trifid verrucae at the proximal ends of the processes in vertical view, in the longer spines near the distal ends of the processes, and the presence of two or three short teeth on the ventral margin of the semicell in front view, which replace the ring of basal granules of the species; these small teeth are not always present. L 28—31; W cpr 39—53; I 9—12. Hab. Java 501, 502, 505.

*Staurastrum dejectum* Bréb. (1840). Pl. 53, Fig. 10.
L ssp 15, csp 20; W ssp 15, csp 21; I 5. Hab. Sumatra 114.

*Staurastrum dentatum* Krieg. (1933). Fa. Pl. 59, Fig. 8.
L spr 16, cpr 19; W cpr 29; I 6.5. Hab. Sumatra 115.

Somewhat smaller than KRIEGER's specimens, with more apical spines, and with processes almost horizontal instead of divergent.

*Staurastrum dickiei* Ralfs fa. *longispinum* Fritsch & Rich (1937). Pl. 41, Fig. 5.

L 38—45; W ssp 33—39, csp 48—57; I 12—13. Hab. Sumatra 112, 148.

*Staurastrum diptilum* Nordst. (1870). Pl. 53, Fig. 11.
L to depressed apex 10, csp 18; W ssp 13, csp 24; I 5. Hab. Sumatra 115.

*Staurastrum distentum* Wolle (1882). Fa. Pl. 59, Fig. 4.
L ssp 24, csp 28; W cpr 37; I 9. Hab. Sumatra 148.

*Staurastrum emaciatum* sp. nov. Pl. 58, Fig. 7.

Cellulae parvae, cum processibus quasi aequae longitudine et latitudine; a fronte visum corpus valde elongatum ac tenuissimum, marginibus subparallelis ac inflatione basali parva praeditum; corpus supra in tres processus tenues convergentes, marginibus serratis atque duobus dentibus terminalibus parvis praeditos, expansum; apex valde convex atque levis. A vertice visum corpus triangulare, lateribus retusis, angulis in processus tenues productis; processus marginibus undulatis praediti, ad extremitates, ad unicum dentem terminalem visibilem formandum, abrupte attenuati.

Cells small, length and width with processes about equal. In front view body greatly elongated and extremely thin, with subparallel margins and a slight basal inflation, upper part of body expanded into three slender convergent processes with serrate margins and two small terminal teeth; apex strongly convex and smooth. In vertical view a triangular body with retuse sides and angles produced into slender processes with undulate margins which are abruptly attenuated at the ends to form a single visible terminal tooth. L 34; W base 6, neck 4, cpr 36; I 4. Hab. Borneo 134, 108—135—146; 206—212.

This very peculiar little plant is quite unlike any other; its nearest counterpart is *St. elongatum* Bark., which is of a very much stouter habit.

*Staurastrum euprepes* sp. nov. Pl. 60, Fig. 3.

Cellulae parvae, cum processibus paululo latiores quam longae. Corpus a fronte visum anguste cyathiforme, in basi inflata tria paria granulorum parvorum ferens; corpus supra in tres processus tenues horizontales expansum, processibus alterius semicellulae alternantibus, margines ventrales dorsalesque profunde serratos, atque duos dentes terminales habentibus; apex convexus, tres verrucas emarginatas ferens. Corpus a vertice visum triangulare, lateribus paululum convexis, angulis in processus tenues attenuatos, marginibus paululum serratis atque duobus dentibus visibilibus terminalibus praeditos,

productis. Superficies apicalis tres verrucas emarginatas intra marginem, unam ad centrum cuiusque lateris, necnon par dentium parvorum ad extremitatem proximalem processuum, necnon ordinem centralem dentium minutorum secundum quemque processum ferens.

Cells small, length somewhat less than width with processes. In front view body narrowly cyathiform, bearing three pairs of small granules on the inflated base; upper part of body expanded into three slender horizontal processes which alternate in position on the two semicells, ventral and dorsal margins of processes deeply serrate, with two terminal teeth; apex convex and bearing three emarginate verrucae. In vertical view a triangular body with slightly convex sides and angles produced into slender tapering processes with slightly serrate margins and two visible teeth at their ends; apical surface bearing three emarginate verrucae intramarginally, one at the center of each side; a pair of small teeth at the proximal end of the processes, and a central row of minute teeth along each process. L 27; W base 6.5. cpr 33; I 4.5. Hab. Borneo 134.

The apical ornament of only three emarginate verrucae is similar to that of *St. triprocessum* Scott & Presc. (1958), but they differ considerably in other respects.

*Staurastrum exporrectum* sp. nov. Pl. 50, Fig. 4.

Cellulae mediocres, ca. duplo longiores quam latae sine processibus, vix constrictae, sinu minimo atque late aperto. Semicellulae a fronte visae anguste trapezoideae, marginibus lateralibus paululum concavis ad humeros admodum infra angulos superiores laterales, in processus perlongos tenues divergentes productos, processibus ad extremitates bifurcatis, margines serratos habentibus; apex retusus, habens in centro depressionem parvam granulo parvo in unoquoque latere praeditam. Semicellulae a latere visae anguste oblongae, marginibus lateralibus retusis, praebentes constrictionem parvam ad isthmum, gibbo parvo utroque in latere, praeditam; poli semicirculares, unoquoque processum longum tenuem, marginibus inconspicue undulatis, cacumine bifurcato, habente.

Cells of moderate size, about twice as long as wide without processes, very slightly constricted, sinus very small and widely open. In front view semicells narrowly trapezoidal, the lateral margins somewhat concave to shoulders just below the upper lateral angles which are produced into very long, slender, divergent processes, bifurcate at their ends, and with serrate margins; apex retuse and with a small depression in the center, on each side of which is a small granule. In side view narrowly oblong with retuse lateral margins and a small constriction at the isthmus, on each side of which is a

small bulge; poles semicircular and each having a long slender process with faintly undulate margins and a bifurcate tip.
L spr 27, cpr 69; W base 8, shoulder 13, cpr 39; I 7; T 9. Hab. Sumatra 110, 114.

The extraordinary elongated shape of this plant gives it a „stretched-out" appearance, whence the specific epithet. We know of no other *Staurastrum* with which it can be compared.

*Staurastrum formosum* Bern. (1908). Pl. 43, Figs. 8—10.
L ssp 33—36, csp 46—49; W csp 54—70; I 14. Hab. Java M & P, 501A; Sumatra 102.

There are usually three spines at each angle, but in some specimens the number may be reduced to two, or increased to four or five. G. S. West (1909) considered *St. formosum* as a synonym of *St. ensiferum* Turn.

*Staurastrum freemanii* West & West (1902). Pl. 43, Fig. 1.
L spr 27, cpr 51; W spr ca. 30, cpr 72; I 9; T ca. 16. Hab. Sumatra 149.

*Staurastrum freemanii* West & West var. *evolutum* Scott & Presc. (1958a). Pl. 43, Fig. 5.
L spr 30, cpr 60; W cpr ca. 30—33, cpr 63—72; I 10. Hab. Borneo X, 38; Sumatra 148.

*Staurastrum freemanii* West & West var. *nudiceps* Scott & Presc. (1958a). Pl. 43, Fig. 3.
L ssp 30, csp 54—60; W ssp 30—33, csp 63—72; I 10. Hab. Borneo X, 38; Sumatra 148.

*Staurastrum freemanii* West & West var. *nudiceps* Scott & Presc. fa. *biradiatum* Scott & Presc. (1958a). Pl. 43, Fig. 4.
L ssp 30, csp 48; W ssp 36, csp 68; I 10; T 18. Hab. Sumatra 148.

*Staurastrum freemanii* West & West var. *triquetrum* West & West (1902). Pl. 43, Fig. 2.
L ssp 30, csp 49; W ssp 27, csp 62; I 10. Hab. Borneo 38; Sum. 148.

*Staurastrum furcatum* (Ehrbg.) Bréb. (1856) var. *aristeron* var. nov. Pl. 57, Figs. 4—6.

Varietas a species differens possessione processus additicii asymmetrice positi in latere sinistro cuiusque anguli; differens necnon eo quod quisque angulus tres spinas vice duarum interdum habet, quodque nonnulli omnesve processus tres spinas interdum habet

Differs from the species in the possession of an asymmetrically placed extra process on the left side of each angle; also differs in that there may be three spines at each angle instead of two, and that some or all of the processes may have three spines.

L spr 30—33, cpr 45—52; W csp 48—66; I 12—15. Hab. Java P, Z, 501; Sumatra 104

This is of similar structure to var. *scaevum* Scott & Grönbl. (1957) but considerably larger and with the spination more highly developed. It should be compared with *St. seelyanum* Bern. (1908) and with *St. forficulatum* var. *africanum* Bourr. (1957).

*Staurastrum gladiosum* Turn. (1892). Pl. 56, Fig. 1.
L ssp 35, csp 45; W ssp 32, csp 45; I 10. Hab. Java 505.

*Staurastrum gnampton* sp. nov. Pl. 60, Fig. 2.

Cellulae parvae delicataeque, longitudine minore triente quam latitudine cum processibus, constrictione media parte, sinu late aperto. Corpus semicellulae a fronte visum anguste cyathiforme, basi bulbosa, tria granula parva, uno sub quoque processu, ferente. Corpus ad fastigium expansum, angulis in processus longos tenues deorsum abrupte deflexos, quattuor dentes terminales minimos ferentes, productis; margines ventrales processuum minute serrati, dorsales crenulati; apex depressus, nonnullos dentes minutos aut verrucas ferens. Corpus a vertice visum triangulare, marginibus concavis, angulis in processus longos tenues dextrorsum venuste curvatos productis; corpus admodum intra quemque marginem lateralem serie quattuor dentium acutorum minutorum, praeditum, dentes in nonnullis exemplis velut paria granulorum verrucas emarginatas indicantia videntur; processus duo paria opposita verrucarum emarginatarum ad extremitatem proximales habentes, reliquo processu margines crenulatos, atque lineas transversas, quae corrugationes aut crenationes indicatant, habente.

Cells small and delicate, length about two-thirds the width with processes; median constriction small, sinus widely open. In front view body narrowly cyathiform with a bulbous base that bears three small granules, one under each process; body expanded to the top and angles produced into long slender processes that are abruptly bent downward and bear four very small terminal teeth; ventral margins of processes minutely serrate, dorsal margins crenulate; apex depressed and bearing some minute teeth or verrucae. In vertical view a triangular body with concave margins and angles produced into long slender processes that are gracefully curved in a clockwise direction; just within each lateral margin of the body a series of four minute teeth, which in some specimens appear as

pairs of granules indicating emarginate verrucae; at the proximal end of each process two opposed pairs of emarginate verrucae, remainder of process with crenulate margins and cross lines indicating corrugations or crenations.

L 22—24; W base 8, cpr 33—38: I 5. Hab. Sumatra 114, 115.

Because of the small size and delicate structure of this plant the markings are difficult to distinguish and interpret. In some specimens the apical markings are clearly sharp teeth; in others they appear as pairs of small dots which show as emarginate verrucae in oblique view. It should be compared with the American *St. genuflexum* West & West, from which, however, it differs in several respects.

*Staurastrum gracile* Ralfs var. *elongatum* Scott & Presc. (1958). Pl. 57, Fig. 10.

L 29—32; W base 11, cpr 68—76; I 7—8. Hab. Sumatra 148.

*Staurastrum gracile* Ralfs fa. *kriegeri* fa. nov. Pl. 57, Fig. 11.

Differs from the species in the shape of the processes which are convergent in front view. This is the form described and illustrated by Krieger (1933, Pl. 18, Fig. 12).

L 18—20; W cpr 27—29; I 5—6. Hab. Java 505; Sumatra 148.

*Staurastrum gutwinskii* Bern. (1908) var. *brevispinum* var. nov. Pl. 43, Fig. 6.

Varietas differens eo quod cellulae paululo minores quam in specie, quodque margines ventrales semicellularum leves, quodque spinae ad angulos multo breviores sunt.

Cells a little smaller than in the species; differs in the smooth ventral margins of the semicells, and in the much shorter spines at the angles. L ssp 30—33, csp 33—36; W ssp 30—37, csp 39—48; I 10—12. Hab. Sumatra 109; Bali F.

*Staurastrum gutwinskii* Bern. (1908) var. *evolutum* var. nov. Pl. 43, Fig. 7.

Varietas quasi eadem magnitudine ut species, differens eo quod tres spinas late divergentes ad quemque angulum habet, quodque processus apicales profundius furcati, isthmus multo latior, margines semicellularum ventrales fere leves sunt.

Cells about the same size as in the species. Differs in having three widely divergent spines at each angle, apical processes more deeply furcate, much wider isthmus, and smooth ventral margins of the semicells. L spr 30, cpr 42; W spr 30, cpr 57; I 16. Hab. Java Z.

*Staurastrum gyratum* West & West (1907) var. *dextrum* var. nov. Pl. 59, Fig. 12.

Varietas quasi eadem magnitudine ut species; differens eo quod processus divergentes non paralleli, quodque quattor dentes terminales vice trium habent, quodque a vertice visi dextrorsus non sinistrorsus torti sunt.

Cells about the same size as in the species. Differs in the processes which are divergent instead of parallel, and with four terminal teeth instead of three, and in vertical view twisted to the right instead of to the left. L spr 12, cpr 22; W cpr 31; I 6. Hab. Sumatra 115.

Compare with *St. triforcipatum* var. *divergens* Krieg. (1933).

*Staurastrum heimerlianum* Lütkem. (1893) var. *sumatranum* var. nov. Pl. 56, Fig. 10.

Cellula a fronte visa cellulae speciei forma similis. A vertice visa differt eo quod margines laterales processuum undulationibus, non spinis, praediti sunt; spinae in superficiebus processuum tantummodo dorsalibus ventralibusque repertae.

In front view shape of cell similar to that of the species. In vertical view differs in that the lateral margins of the processes are undulate and without spines, the spines being confined to the dorsal and ventral margins of the processes.

L spr 16, cpr 21; W cpr diag. 39; I 9. Hab. Sumatra 149.

*Staurastrum „hexops"* sp. nov.? Pl. 42, Fig. 7.

L ca. 60; W 56; I 24. Hab. Sumatra 149.

Only one empty semicell has been seen, and careful search failed to reveal another. We do not know whether it is a normal or abnormal form, and therefore are not giving a formal description. It should be compared with the abnormal semicell of *St. tauphorum* shown in our Pl. 47, Fig. 3, which, though very much smaller, has some similar characteristics. If in the future the plant should prove to be normal we suggest the epithet „*hexops*" as being appropriate.

*Staurastrum horametrum* Roy & Biss. (1893) var. *orientale* var. nov. Pl. 56, Fig. 3.

Varietas a fronte visa differens forma cellularum ad isthmum acutius constrictarum, atque in marginibus semicellularum ventralibus indentationem perspicuam praebentium. Semicellula a vertice visa 4-radiata non triangularis, spinas pauciores in lobis, atque septem poros magnos in centro superficiei apicalis habens.

In front view differs in the shape of the cells, which are more sharply constricted at the isthmus and have a distinct indentation on the ventral margin of the semicells. In vertical view 4-radiate instead of triangular, with fewer spines on the lobes, and with a group of seven large pores in the center of the apical surface. L 30; W ssp diag. 29, csp 32; I 9. Hab. Sumatra 149.

*Staurastrum hypacanthum* sp. nov. Pl. 49, Fig. 5.

Cellulae mediocres paululo longiores quam latae (sine spinis), profundius constrictae, sinu intus acuto sed externe aperto. Semicellulae a fronte visae subellipticae, marginibus ventralibus convexioribus quam margo apicalis; unusquisque angulus lateralis una spina curvata declivi, atque, aliquantum infra hanc spinam, pari spinarum similium praeditus. Semicellulae a vertice visae triangulares,marginibus concavis in centro, convexis prope angulos in spinam rectam tenuem productos; unoquoque margine laterali ad loca convexitatis maximae duabus spinis satis longis, infra marginem visibilem enascentibus, praedito.

Cells of medium size, a little longer than wide (without spines), rather deeply constricted, sinus acute within but open outwardly. In front view semicells subelliptical, the ventral margins more strongly convex than the apical margin; at each lateral angle a single long spine sloping downward, and considerably below this a pair of similar spines. In vertical view triangular, with lateral margins concave in the center and convex near the angles which are producted into a long slender straight spine; on each lateral margin at the points of greatest convexity two fairly long spines which arise at a lower level than the visible margin.

L 48; W ssp 44, scp 66; I 16. Hab. Borneo X.

This shows a certain similarity to *St. minneapoliense* Wolle, but is distinguished by the lateral spines which arise at a level that is about half-way between the isthmus and the lateral angles.

*Staurastrum inconspicuum* Nordst. (1873). Pl. 59, Fig. 11.

L spr 10, cpr 16; W cpr 18; I 6. Hab. Sumatra 114, 147, 148, 149.

*Staurastrum indentatum* West & West (1902). Formae. Pl. 50, Figs. 6, 7.

L 42—46; W base 11—12, cpr 73—76; I 7—8; T 16. Hab. Java M & P; Sumatra 148.

This plant is identical with the Australian one that was wrongly identified as a *forma* of *St. longebrachiatum* var. *pseudoanchora* Krieg. in our Arnhem Land paper (1958). Both the Indonesian and Australian specimens are less strongly inflated in vertical view than those from Ceylon. Our illustration Pl. 50, Fig. 7 shows a specimen that has three rows of small verrucae or teeth on the dorsal margin of the processes, an unusual feature.

*Staurastrum indentatum* West & West (1902) fa. *minus* fa. nov. Pl. 50, Figs. 8, 9.

*Staurastrum* forma ornatuque speciei simile, sed multo minus atque processus breviores habens.

Similar to the species in shape and ornament, but much smaller and with shorter processes. L 35—36; W base 11, cpr 52—58; I 8; T 15—16. Hab. Java 501a; Borneo 430.

*Staurastrum javanicum* (Nordst.) Turn. var. *apiculiferum* (Turn.) Krieg. (1933). Pl. 44, Fig. 6.
L spr 46, cpr 51; W base 19, cpr 72; I 15. Hab. Java T; Sumatra 102, 148.

*Staurastrum laeve* Ralfs (1848). Pl. 58, Fig. 9.
L spr 11, cpr 18; W cpr 22; I 5. Hab. Sumatra 101.

*Staurastrum limneticum* Schm. var. *burmense* West & West (1907). Pl. 42, Figs. 2, 3.
4-radiate specimens,
Borneo: L spr 27—30, cpr 60; W cpr 79—84; I 8—9.
6-radiate specimens,
Sumatra: 34 57 92 12.
Hab. Borneo 38, 43; Sumatra 114; Bali F.

*Staurastrum longebrachiatum* (Borge) Gutw. (1902). Pl. 50, Fig. 5.
L 40; W cpr 92; I 9; T 19. Hab. Borneo 134, 206—212.

*Staurastrum margaritaceum* (Ehrbg.) Menegh. var. *gracilius* Scott & Grönbl. (1957). Pl. 59, Fig. 16.
L spr 18, cpr 22—24; W cpr diag. 25—27; I 6—7. Hab. Java 505; Sumatra 148.
Both 3- and 4-radiate forms were seen.

*Staurastrum megacanthum* Lund. (1871). Fa. Pl. 55, Fig. 3.
L 27; W ssp 30, csp 36; I 8. Hab. Java 505.

*Staurastrum megacanthum* Lund. var. *kalimantanum* var. nov. Pl. 55, Fig. 4.
Varietas a fronte visa speciei similis, spinis, autem, longioribus. Semicellula a vertice visa triangularis, marginibus paululum concavis, arcus spinis perlongis fere continuos formantibus.
Front view similar to that of the species, but with longer spines. In vertical view triangular with slightly concave margins that form almost continuous curves with the very long spines. L 27; W csp 66; I 6. Hab. Borneo 108—135—146.
The vertical view is very much like that of *St. curvatum* in West & West, Monograph V, Pl. CXXX, but the front view is quite different.

*Staurastrum megacanthum* Lund. var. *orientale* var. nov. Pl. 55, Figs. 5, 6.

Varietas a fronte visa speciei similis, apice, autem, fere plano aut paululum retuso, spinis longioribus. Semicellula a vertice visa triangularis, marginibus lateralibus concavis in centro, paululum convexis prope angulos in spinas rectas longasque productos.

In front view similar to the species, but with apex almost flat or somewhat retuse, and longer spines. In vertical view triangular with lateral margins concave in the center and slightly convex near the angles which are produced into long straight spines.

L 21—32; W ssp 28—38, csp 45—96; I 6—9. Hab. Sumatra 101, 108, 109.

*Staurastrum megacanthum* Lund. var. *orientale* nob. fa. *biradiatum* fa. nov. Pl. 55, Figs. 7, 8.

*Staurastrum* a fronte visum forma var. *orientali* simili, sed apice plerumque paululum convexo atque spinis super horizontalem lineam paululum elevatis. Semicellulae a vertice visae plerumque biradiatae, corpore fusiformi, necnon, autem, triradiatae, necnon cellulae interdum dichototypicae, 2- atque 3-radiatas semicellulas coniungentes.

In front view shape similar to that of var. *orientale*, but with apex usually slightly convex, and with spines raised slightly above the horizontal. In vertical view usually biradiate with fusiform body, but also triradiate, and with dichotypical cells combining 2- and 3-radiate semicells. L ssp 27, csp 31—33; W ssp 36—40: csp 64—67; I 7; T 14. Hab. Sumatra 101, 148. Dichotypical cells in Sumatra 148.

The biradiate form looks like the much larger *Arthrodesmus fusiformis* West & West, but is assigned to *St. megacanthum* var. *orientale* because of the dichotypical cells which occur in the same collection, Sumatra 148.

*Staurastrum menggalense* sp. nov. Pl. 59, Fig. 15.

Cellulae parvae, paululo breviores quam latae cum processibus, paululum constrictae, sinu parvo atque late aperto. Semicellulae a fronte visae elongatae, basi bulbosa, anulum 15 granulorum minutorum ferente; pars superior semicellulae in tres processus crassissimos, marginibus undulatis serratisve atque extremitatibus rotundatis, quinque vel sex dentes ferentibus, atque duobus tribusve ordinibus intramarginalibus granulorum minutorum praeditos, extendit. Semicellulae a vertice visae triangulares aut quadrangulares, marginibus concavis serratisque, in processus valde attenuatos aequaliter extensis; semicellulae ordine curvato intramarginali granulorum minutorum serrationibus marginalibus congruentium, atque uno

duobusve granulis additiciis ad basim processuum praeditae.

Cells small, length somewhat less than the width with processes, slightly constricted, sinus small and widely open. In front view semicells elongated with a bulbous base bearing a ring of 15 minute granules; upper part of semicell expanded into three very stout processes with undulate or serrate margins, and rounded ends that bear five or six sharp teeth, and two or three intramarginal rows of minute granules. In vertical view triangular or quadrangular with serrate concave margins that merge into the strongly attenuated processes; intramarginally a curved row of minute granules corresponding to the marginal serrations and one or two extra granules at the base of the processes. L 21; W base 7, cpr 24—26; I 5. Hab. Sum. 114, 115.

Both 3- and 4-radiate forms have been seen. The plant should be compared with *St. fernaldii* Taylor (1935) and *St. zygaena* West & West (1896), both from North America.

*Staurastrum multispiniceps* sp. nov. Pl. 44, Fig. 7.

Cellulae mediocres, cum processibus latiores triente quam longae; paululum constrictae, sinu parvo atque late aperto. Semicellulae a fronte visae cyathiformes, basi paululum inflata, parte superiore in tres processus longos tenuesque, marginibus ventralibus serratis, dorsalibus dentatis, atque quattuor dentibus terminalibus praeditos, expansa; apex convexus, aliquot spinas conicas parvas ferens. Semicellulae a vertice visae corpus triangulare, lateribus rectis, angulis in processus longos tenuesque productis, habentes; processus marginibus inconspicue undulatis atque ordine centrali dentium minutorum atque quattuor spinis terminalibus praediti; regio apicalis tres ordines intramarginales sex spinarum conicarum parvarum habens.

Cells of medium size, length with processes about two-thirds the width with processes; slightly constricted, sinus small and widely open. In front view semicells cyathiform with a slightly inflated base, upper part expanded into three long slender processes with serrate ventral and dentate dorsal margins, and four terminal teeth; apex convex and bearing several small conical spines. In vertical view a triangular body with straight sides and angles produced into long slender processes with faintly undulate margins, a central row of minute teeth and four terminal spines; apical area with three intramarginal rows each of six small conical spines. L spr 29, cpr 50; W base 10, cpr 70; I 7. Hab. Borneo 108—135—146.

*Staurastrum muticum* Bréb. (1840). Pl. 52, Fig. 11.
L 42; W 36; I 15. Hab. Java M & P.

*Staurastrum ophiura* Lund. var. *horizontale* Scott & Presc. (1958). Pl. 59, Fig. 3. L 36; W base 13, cpr 49; I 10. Hab. Sumatra 105.

*Staurastrum orbiculare* Ralfs var. *denticulatum* Nordst. (1870). Pl. 49, Figs. 7, 8.

L 48—54; W 44—46; I 15—18. Hab. Sumatra 111, 114.

The basal angles, as seen in the center of our front view, are considerably wider than in Americans forms.

*Staurastrum orbiculare* Ralfs var. *depressum* Roy & Biss. (1886). Pl. 52, Fig. 12.

L 24—27; W 25; I 8—9. Hab. Borneo 403; Java 501A; Sumatra 147, 148, 149.

*Staurastrum pentacrinum* Krieg. (1933). Pl. 42, Fig. 4.

W cpr 72. Only one semicell was seen, in collection Sumatra 114, and the front view could not be obtained. It differs from KRIEGER'S illustration in that the sides of the pentagonal body are straight instead of deeply concave.

*Staurastrum peristephes* sp. nov. Pl. 59, Fig. 5.

Cellulae mediocres, crassissimae, multo breviores quam latae cum processibus, profunde constrictae, sinu late aperto. Semicellulae a fronte visae subtrapezoideae, admodum super isthmum tres inflationes parvas, unaquaque tria granula minuta habente, atque inter inflationes ordinem pororum parvarum praebentes; margines ventrales semicellulae curvati duabus verrucis emarginatis magnis praediti; anguli superiores laterales in processus crassos deorsum curvatos producti, processibus duos dentes terminales, margines ventrales verrucosos, habentibus, margine dorsali ferente sex vel septem verrucas magnas altasque magnitudine graduatas, unaquaque duos ad quattuor dentes habente; margo apicalis paululum elevatus, quattuor verrucas visibiles magnas ferens, quarum duae exteriores spinas longas horizontalesque praebent. Semicellula a vertice visa praebens corpus triangulare, lateribus paululum convexis, angulis in processus crassissimos productis; processibus duos dentes terminales atque six vel septem verrucas bifidas ad quadrifidas habentibus; regio apicalis sex verrucas trifidas permagnas in hexagono ordinatas, spina central uniuscuiusque verrucae multo longiore quam aliae, ferens; arealo in centro hexagoni valde porosa.

Cells of medium size and very stout habit, much shorter than width with processes, deeply constricted, sinus widely open. In front view semicells subtrapezoidal; just above the isthmus three small swellings each with three minute granules; between the swellings a row of small pores; the curved ventral margins of semicell with two large emarginate verrucae; upper lateral angles produced into stout downwardly curved processes with two terminal teeth, verrucose ventral

margins, and dorsal margins bearing six or seven large and high verrucae of graduated sizes, each with two to four teeth; apical margin somewhat elevated and bearing four visible large verrucae, of which the outer two show long horizontal spines. In vertical view a triangular body with slightly convex sides, and angles producted into very stout processes with two terminal teeth and six or seven bifid to quadrifid verrucae; apical area bearing six very large trifid verrucae arranged in a hexagon, the central spine of each verruca much longer than the others; the area in the center of the hexagon strongly porose. L 36—38; W cpr 48—60; I 12—13. Hab. Java P, M & P.

*Staurastrum perundulatum* Grönbl. (1920). Fa. Pl. 52, Fig. 9
L spr 8, cpr 27; W spr 8, cpr 29; I 4; T 6. Hab. Sumatra 105.

*Staurastrum perundulatum* Grönbl. (1920) var. *dentatum* var. nov. Pl. 52, Fig. 10.

Varietas forma speciei similis, habens, autem, spinam parvam ad angulos basales utriusque semicellulae; processus multo longiores, tribus vice quattuor dentibus terminalibus praediti; a vertice visi paululum recurvati.

Similar in shape to the species, with the addition of a small spine at the basal angles of each semicell; processes much longer, with three terminal teeth instead of four, and slightly recurved in vertical view. L spr 10, cpr 27; W spr 9, cpr 50; I 6; T 9. Hab. Sumatra 148.

This has some resemblance to *St. depressiceps* var. *protuberans* Scott & Grönbl. (1957).

*Staurastrum pinnatum* Turn. var. *hydra* Krieg. (1933) fa. *supernumerarium* fa. nov. Pl. 46, Fig. 7.

*Staurastrum* magnitudine, forma ornatuque varietati simile, differt autem, possessione verrucae additiciae quadrifidae parve in latere sinistro uniuscuiusque processus principalis.

Similar in size, shape and ornamentation to the variety, but with an extra small quadrifid verruca on the left side of each of the principal processes. L 30; W cpr 44; I 12. Hab. Java P.

*Staurastrum pinnatum* Turn. var. *subpinnatum* (Schm.) West & West fa. *robustum* Krieg. (1933). Pl. 46, Figs. 9, 10.
L 48; W cpr 51; I 15. Hab. Java 505; Bali F.

*Staurastrum playfairi* Scott & Presc. nom. nov. Pl. 52, Fig. 14.

Syn. *St. volans* West & West var. *elegans* Playf. (1913, non 1907).
L spr 22, cpr 43; W base 7, cpr 54; I 5. Hab. Java M & P.

This agrees very well with *St. volans* var. *elegans* Playf. in his paper

„Plankton of the Sydney Water Supply", 1913, Pl. 54, Fig. 23, but this illustration differs greatly from his original illustration of var. *elegans* in „Some new or less-known desmids found in New South Wales", 1907, Pl. 5, Fig. 5. The 1907 drawing is so highly schematized that it is only doubtfully identifiable with *St. volans* West & West from Madagascar. In our figure the number and position of the facial granules are not quite certain because they were seen only with difficulty against the background of the chloroplast

*Staurastrum polymorphum* Bréb. in Ralfs (1848). Fa. Pl. 59, Fig. 14. L cpr 15; W cpr 22; I 6. Hab. Borneo 403; Sumatra 115.

*Staurastrum prainii* West & West (1907) fa. *rotundatum* fa. nov. Pl. 41, Fig. 6.

Longitudo cellularum quasi eadem atque in specie, latitudo aliquantulum minor. Semicellulae a fronte visae rotundiores, apice convexo, haud truncato retusove ut in specie. Semicellula a vertice visa margines laterales in media parte convexos non retusos, atque angulos latius rotundatos praebens.

Length of cells about the same as in the species, width rather less. In front view semicells more rotund, apex convex and not at all truncate or retuse as in the species. In vertical view lateral margins slightly convex in the center instead of retuse, and angles more widely rounded. L 81—91; W ssp 66—78, csp 70—84; I 27—36. Hab. Sumatra 107, 114.

*Staurastrum prionotum* sp. nov. Pl. 50, Fig. 10.

Cellulae corpus satis parvum sed processus perlongos habentes; latitudine cum processibus ca. quattuor plo maiore quam longitudo sine processibus; modice constrictae, sinu parvo atque late aperto. Semicellulae a fronte visae cyathiformes, parte superiore corporis late expansa, angulis lateralibus in processus perlongos tenuesque productis; processus quattuor dentibus terminalibus magnis, marginibus ventralibus serratis, marginibus dorsalibus undulatis, spina parva acutaque in unaquaque crista, praediti; apex elevatus, depressionem centralem parvam atque duas verrucas bifidas visibiles praebens. Semicellula a vertice visa corpus inflatum parvum, quattuor verrucas atque par granulorum parvorum ad basem utriusque processus ferens, habet; processus perlongi tenuesque, quattuor spinis terminalibus atque serie media dentium minutorum praediti.

Body of cells rather small, but processes very long; width with processes about four times the length without processes; moderately constricted, sinus small and widely open. In front view semicells cyathiform, upper part of body widely expanded, lateral angles

produced into very long, slender processes with four large terminal teeth, ventral margins of processes serrate, dorsal margins undulate and with a small sharp spine on each crest; apex elevated with a small central depression and bearing two visible bifid verrucae. In vertical view biradiate with a small inflated body, four bifid verrucae, and a pair of small granules at the base of each process; processes very long and slender, with four terminal spines and a central series of minute teeth. L spr 29—30; cpr 42—46; W cpr 105—129; I 9; T 11—13. Hab. Borneo 108—135—146, 213.

There is some resemblance to *St. octoverrucosum* var. *simplicius* Scott & Grönbl. (1957), which has a differently shaped body and only two terminal spines on the processes.

*Staurastrum prionotum* Scott & Presc. fa. *triradiatum* fa. nov. Pl. 50, Fig. 11.

Forma a specie differens quod triradiata vice biradiata.

Differs only in being triradiate instead of biradiate. L spr 29, cpr 42; W cpr 105; I 9. Hab. Borneo 213.

One dichotypical cell was seen combining the bi- and triradiate forms, and another dichotypical in which the triradiate semicell was imperfectly developed.

*Staurastrum protectum* West & West (1907) var. *rangoonense* (Skuja) Scott & Presc. comb. nov. Pl. 44, Figs. 1, 2.
L spr 30, cpr 49—64; W cpr 60—87: I 9—10. Hab. Borneo H, 134, 108—135—146.

This agrees almost exactly in size, shape and ornamentation with the plant described by Skuja (1949) as *St. lacustre* G. M. Smith var. *rangoonense* var. nov., but we are convinced that it is not in any way related to the American *St. lacustre* which has a greatly different structure. On the other hand, both Skuja's plant and ours agree perfectly with the *vertical* view of *St. cyathodes* Joshua (1886) from Burma, but not with his *front* view. It seems to us impossible to reconcile Joshua's front and vertical views of *St. cyathodes*; in fact the front view gives us the impression of having been drawn not only from a different specimen but from a different species, unless, perchance, the specimen was in an early stage of division with the new semicells still in the bulbous stage and merely touching at their rounded apices, which might account for the impossibly small dimension of 3 $\mu$ which he gives for the width of the isthmus. West & West (1907) also pointed out that their *St. protectum* resembles the vertical view of *St. cyathodes* except in the feature of the apical ornament, but not the front view. It is regrettable that some of Joshua's drawings are so poor as to be almost or quite unidentifiable, but for

the present it seems best to ignore *St. cyathodes*, and so we have referred our plant and SKUJA'S to *St. protectum* as a new variety.

*Staurastrum pseudopachyrhyncum* Wolle (1884). Pl. 52, Fig. 13. L 31; W 29; I 7. Hab. Sumatra 114.

This species differs from *St. pachyrhyncum* in that there is no thickening of the wall at the lateral angles.

*Staurastrum pseudozonatum* Borge (1899) var. *minutum* var. nov. Pl. 59, Fig. 13.

Varietas a specie differens quod minima, quodque processus breviores crassioresque, atque dentes supraisthmiales binos non quaternos habet. Semicellula a vertice visa plerumque 4-radiata, interdum, autem, 5-radiata.

Differs in the very small size, the shorter and stouter processes and the groups of suspraisthmian teeth which are in pairs instead of groups of four. In vertical view usually 4-radiate but occasionally 5-radiate. L spr 24, cpr 27; W base 12, cpr 24; I 9. Hab. Sumatra 149.

*Staurastrum punctulatum* Bréb. in Ralfs (1848). Fa. Pl. 52, Fig. 14. L 30; W 35; I 8. Hab. Sumatra 148.

In our specimens the wall ornament consists of small conical teeth, not rounded circular granules.

*Staurastrum quadricornutum* Roy & Biss. (1886). Pl. 59, Fig. 6. L spr 23—27, cpr 33—34; W cpr 33—34; I 11. Hab. Borneo 403.

*Staurastrum rhaphidacanthum* sp. nov. Pl. 55, Fig. 9.

Cellulae mediocres, modice constrictae, sinu obtuso late aperto. Semicellulae a fronte visae subtrapezoideae, marginibus ventralibus paulum convexis, versus angulos superiores divergentibus; anguli superiores in processus longos leves cavos attenuatosque, tribus spinis terminalibus perlongis acutis aciformibusque munitos, producti; apex convexus ac levis. Semicellulae a vertice visae 4-radiatae, corpore rectangulari, latera fere recta habente, angulis in processus supra descriptos productis, processibus alterius semicellulae alternantibus. Membrana omnino levis.

Cells of medium size, moderately constricted, sinus obtuse and widely open. In front view semicells subtrapezoidal, the ventral margins very slightly convex and diverging to the upper angles which are produced into long, smooth, hollow, tapering processes tipped with three very long, sharp, needle-like spines; apex convex and smooth. In vertical view 4-radiate, the body rectangular with almost straight sides, the angles produced into the processes described

above; processes alternating on the two semicells. No wall markings of any kind. L ssp 18, csp 54; W csp 60; I 9. Hab. Sumatra 114.

*Staurastrum rhynchoceps* Krieg. (1933) var. *curvatum* var. nov. Pl. 56, Figs. 8, 9.

Longitudo cellularum eadem atque in specie, latitudo diagonalis paululum maior. Cellula a fronte visa differt possessione anuli dentium minutorum acutorumque super infraque isthmum. A vertice visa differt eo quod processus longiores tenuioresque, venuste dextrorsus curvatos habet.

Length of cells the same as in the species, diagonal width somewhat greater. In front view differs in the possession of a ring of minute sharp teeth above and below the isthmus. In vertical view differs in the longer and more slender processes which are gracefully curved in a clockwise direction. L 34; W diag. cpr 46—48; I 8—9. Hab. Sumatra 109, 114, 149.

*Staurastrum rosei* Playf. (107). Formae. Pl. 58, Figs. 1, 2.

In the Indonesian material this plant occurs in two forms: (a) with shorter horizontal processes; (b) with longer horizontal processes:

| | | | | |
|---|---|---|---|---|
| (a) Java 501. | L spr 24—27, | cpr 46—49; | W cpr 51—54; | I 9—10. |
| (b) Sumatra 130. | 27—30 | 50—54 | 64—72 | 10—11. |

*Staurastrum rosei* Playf. (1907). var. *stemmatum* var. nov. Pl. 58, Fig. 3.

Varietas differens praecipue possessione apici magis elevati, coronam sex dentium acutorum parvorum ferentis.

Differs principally in the more elevated apex which bears a crown of six small sharp teeth. L spr 28, cpr 49; W cpr 52; I 9. Hab. Java 502, 505.

*Staurastrum saltans* Josh. var. *javanicum* Scott & Presc. (1958a). Pl. 51, Figs. 8, 9.
L ssp 36—37, csp 39—41; W cpr 48—70; I 10—11; T 25—27. Hab Java 505.

*Staurastrum saltans* Josh. var. *kalimantanum* Scott & Presc. (1958a). Pl. 51, Fig. 6.
L ssp 39, csp 43; W cpr 88; I 12; T 27. Hab. Borneo X.

*Staurastrum saltans* Josh. var. *polycharax* Scott & Presc. 1958a).) Pl. 51, Fig. 7.
L ssp 39—42, csp 50—54; W cpr 72—88; I 8—11; T 24—30. Hab. Java T.

*Staurastrum saltans* Josh. var. *sumatranum* Scott & Presc. (1958a). Pl. 51, Figs. 3, 4.
L ssp 33—38, csp 40—42; W cpr 85—100; I 9—10; T 21. Hab. Sumatra 100, 108, 114.

*Staurastrum saltans* Josh. var. *sumatranum* Scott & Presc. fa. *divergens* Scott & Presc. (1958a). Pl. 51, Fig. 5.
L spr 33, cpr 44; W cpr 85; I 9. Hab. Sumatra 100.

*Staurastrum sebaldi* Reinsch var. *ornatum* Nordst. (1873). Pl. 44, Fig. 4.
L 57; W base 16, cpr 82; I 12. Hab. Sumatra 148. Cf. Scott & Presc. Arnhem Land, (1958), Pl. 18, Fig. 10.

*Staurastrum sebaldi* Reinsch (1867) var. *ventriverrucosum* var. nov. Pl. 44, Fig. 5.

Cellulae mediocres, latiores ca. triente quam longae, crassissimae, profunde constrictae, sinu aperto. Semicellulae a fronte visae subellipticae, angulis lateralibus in processus brevissimos crassosque, duobus dentibus terminalibus praeditos, productis; margines ventrales semicellularum processuumque ca. sex verrucas emarginatas bifidas ad quadrifidas ferentes; margo dorsalis quoque ca. octo verrucas similes ferens. Semicellula a vertice visa triangularis, margines profunde concavos processibus contiguos habens; processus ad extremitates anguste rotundati, unicum dentem terminalem visibilem, altero dente minore ad basin interdum visibili habentes; semicellula intra margines habens tres ordines curvatos verrucarum emarginatarum bifidarum ad quadrifidas, quarum sex prope centrum maiores atque ad angulum alium positae, hexagonum formantes.

Cells of medium size, about one-third wider than long, deeply constricted, very stout habit, sinus open. In front view semicells subelliptical, the lateral angles produced into very short stout processes with two terminal teeth; ventral margins of semicells and processes bearing about six emarginate bifid to quadrifid verrucae; dorsal margin also with about eight similar verrucae. In vertical view triangular with deeply concave margins continuous with the processes which have narrowly rounded ends and a single visible terminal tooth with sometimes another smaller tooth visible at its base; intramarginally three curved rows of emarginate bifid to quadrifid verrucae, of which a group of six near the center are larger than the others and set at a different angle, forming a hexagon. L 39; W cpr 51; I 12. Hab. Java 505.

This is similar to the plant described as *St. sebaldi* fa. in Scott & Prescott, Arnhem Land, (1958, Pl. 17, Fig. 12). Compare, also, *St. proboscideum* Bern. (1908) Figs. 268—269.

*Staurastrum senarium* (Ehrbg.) Ralfs (1848). Formae. Pl. 57, Figs. 7—9.
L spr 25—27, cpr 33—37; W cpr 30—37; I 9—10. Hab. Java 502, 505; Sumatra 148.

*Staurastrum setigerum* Cleve (1864). Pl. 56, Fig. 2.
L ssp 36, csp 43; W ssp 36, csp 54; I 13. Hab. Java Z.

*Staurastrum sexangulare* Lund. (1871). Fa. Pl. 46, Fig. 6.
L spr 30, cpr 51; W cpr diag. 63; I 9. Hab. Sumatra 102.

This bears some resemblance in front view to *St. rosei* Playf., but differs in that most of the processes have three terminal teeth, and that these teeth are of a different type from the inflated lobules of *St. rosei*. Compare Scott & Prescott, 1958, Pl. 18, Fig. 9, and Borge 1896, Pl. 2, Fig. 33.

*Staurastrum sexangulare* Lund. var. *asperum* Playf. (1910). Pl. 45, Figs. 1—3.
L spr 57, cpr 99; W cpr 78—100; I 18. Hab. Java T, 505.

*Staurastrum sexangulare* Lund. var. *attenuatum* Turn. (1892). Pl. 46, Fig. 5.
L spr 33—34, cpr 46—66; W cpr 66—75; I 10—11. Hab. Sumatra 130.

*Staurastrum sexangulare* Lund. var. *bidentatum* Gutw. (1902). Pl. 45, Figs. 4, 5.
L spr 48, cpr 104; W cpr 121; I 18. Hab. Borneo 404.

*Staurastrum sexangulare* var. *bidentatum* Gutw. fa. *crassum* fa. nov. Pl. 46, Figs. 6, 7.

Varietas differt eo quod crassior, quodque verrucas magis evolutas in marginibus dorsalibus processuum lateralium, quodque dentes truncatos emarginatosve in processibus apicalibus habet.

Differs in the much stouter habit and the greater development of the verrucae on the dorsal margins of the lateral processes, also in the truncate or emarginate terminal teeth on the apical processes.
L spr 63, cpr 90; W cpr 102; I 27. Hab. Java T.

*Staurastrum sexangulare* Lund. var. *productum* Nordst. (1887). Pl. 46, Figs. 3, 4.
L spr 35, cpr 54; W cpr 75; I 11. Hab. Sumatra 148.

*Staurastrum sexangulare* Lund. var. *subglabrum* West & West (1902). Pl. 46, Figs. 1, 2.
L spr 36, cpr 69; W cpr 75—90; I 11—12. Hab. Sumatra 114, 148.

*Staurastrum smithii* (G. M. Smith) Teiling (1946). Pl. 52, Figs. 5, 6. L spr 12; W cpr 60; I 6; T 7.5. Hab. Java K; Bali F.

*Staurastrum spiniceps* Krieg. (1933). Pl. 58, Fig. 4.
L spr 29, cpr 40—41; W cpr diag. 64—72; I 9. Hab. Sumatra 114, 115.

*Staurastrum spiniceps* Krieg. (1933) var. *trifidum* var. nov. Pl. 58, Fig. 5.

Longitudo quasi eadem atque in specie, latitudo cum processibus minor ob processus breviores. Varietas differt eo quod triradiata non quadriradiata, differt necnon proprietate ornatus basalis, necnon marginibus processuum prominentius serratis, necnon verrucis apicalibus trifidis non bifidis.

Length about the same as in the species, width with processes less because of the shorter processes. Differs in being triradiate instead of quadriradiate; in the character of the basal ornament; in the more prominently serrate margins of the processes; and in the apical verrucae which are trifid instead of bifid. L spr 27—33; cpr 33—45; W base 9—12, cpr 45—60; I 7—10. Hab. Borneo 206—212; Java M & P; Sumatra 108, 114, 115.

*Staurastrum spinipendens* sp. nov. Pl. 44, Fig. 3.

Cellulae minores, longitudine sine processibus ca. 4/10 latitudinis cum processibus, paululum constrictae, sinu parvo atque late aperto. Semicellulae a fronte visae cyathiformes, parte superiore in tres processus fere horizontales longos tenuesque, tres dentes terminales ferentes, late expansa; margines ventrales processuum undulati, margo dorsalis in dimidio distali serratus, in dimidio proximali ca. quinque verrucas bifidas magnitudine graduatas ferens; apex convexus ac levis; semicellula praebens utroque in latere lineae mediae verticalis duas verrucas subapicales trispinatas, utraque spinas duas breves atque unam perlongam habente, spina perlonga externa curvata, infra marginem semicellulae superiore lateralem pendente. Semicellula a vertice visa praebens corpus triangulare habens margines biundulatos e quibus unoquoque in latere duae verrucae rotundatae ac trispinatae eminent unaquaque verruca duas spinas breves atque unam spinam perlongam atque paululum curvatam habente; anguli corporis in processus longos tenuesque extensi; processus tres dentes terminales, atque duos ordines marginales dentium minutorum in dimidio distali, atque ca. quinque verrucas bifidas in dimidio proximali habentes; superficies apicalis levis.

Cells rather small, length without processes about 4/10 of width with processes, slightly constricted, sinus small and widely open. In

front view semicells cyathiform, the upper part widely expanded into three long, slender, almost horizontal processes bearing three terminal teeth; ventral margins of processes undulate, dorsal margins serrate on the distal half, the proximal half bearing about five bifid verrucae of graduated sizes; apex convex and smooth; subapically on each side of the vertical centerline two trispinate verrucae, each with two short and one very long spine, the latter curved outwardly and hanging down below the upper lateral margin of the semicell. In vertical view a triangular body with biundulate margins from which project on each side two rounded trispinate verrucae each with two short and one very long and slightly curved spines; angles of body extended into long and slender processes with three terminal teeth, on the distal half of the processes two marginal rows of minute teeth, and on the proximal half about five bifid verrucae; apical surface smooth. L 31; W cpr 82; I 8. Hab. Sumatra 101, 108.

We have also found this species in new material from North Australia, identical in structure, and with only minor differences.

*Staurastrum stauroton* sp. nov. Pl. 58, Fig. 6.

Cellulae satis parvae, cum processibus latiores triente quam longae, paululum constrictae, sinu parvo et late aperto. Semicellulae a fronte visae cyathiformes, habentes basim modice inflatam quattuor granula parva hemispherica, unum sub unoquoque processu ferentem; pars semicellulae superior expansa, angulis in processus satis longos, quattuor dentibus terminalibus et marginibus ventralibus dorsalibusque undulatis, et ordine centrali granulorum minutorum praeditos productis; apex paululum elevatus, quattuor verrucas emarginatas visibiles praebens. Semicellulae a vertice visae cruciformes; margines corporis undulati, unoquoque spinas duas breves atque duas longiores ferente, corpus intra marginem ferens quattuor ordines curvatos, unoquoque quinque verrucas emarginatas magnitudine graduatas habente; omnes quattuor processus quattuor dentes terminales ferentes, margines undulatos et duos ordines intramarginales granulorum minutorum habentes.

Cells rather small, length about two-thirds of the width with processes, slightly constricted, sinus small and widely open. In front view semicells cyathiform with moderately inflated base which bears four small hemispherical granules, one under each process; upper part of semicell expanded and angles produced into moderately long processes with four terminal teeth and undulate ventral and dorsal margins and a central row of minute granules; apex somewhat elevated with four visible emarginate verrucae. In vertical view cruciform; margins of the body undulate and each bearing two short and two longer spines, intramarginally four curved rows each of five

emarginate verrucae of graduated sizes; each of the four processes bearing four terminal teeth, and having undulate margins and two intramarginal rows of minute granules. L 31—33; W cpr diag. 45—48; I 8. Hab. Sumatra 114, 115.

*Staurastrum subgracillimum* West & West var. *tortum* Scott & Grönbl. (1957). Pl. 53, Fig. 7.
L spr 15, cpr 20; W cpr 42—48; I 7. Hab. Java 501A, 502, 505.
Somewhat larger than the American form, otherwise in agreement. Compare also var. *curvatum* Behre (1956).

*Staurastrum sublaevispinum* West & West (1898). Pl. 53, Fig. 5.
L spr 18, cpr 27; W cpr 36; I 9. Hab. Sumatra 114.
In the few specimens seen there was a small dark granule at the tip of each process, the nature of which could not be ascertained.

*Staurastrum subsaltans* West & West var. *indonesianum* Scott & Presc. (1958a). Pl. 52, Fig. 1.
L 36—42; W base 9—10, cpr 58—81; I 7; T 13—17. Hab. Borneo K, 38, 43; Sumatra 114.

*Staurastrum subsaltans* West & West var. *indonesianum* Scott & Presc. fa. *divergens* Scott & Presc. (1958a). Pl. 52, Fig. 2.
L spr 34, cpr 47; W base 9, cpr 67—73; I 7—8; T 15. Hab. Sumatra 108, 114.

*Staurastrum subsuecicum* sp. nov. Pl. 52, Fig. 3.
Cellulae minores, cum processibus ca. $1\frac{1}{2}$-plo latiores quam longae, non profunde constrictae, sinu parvo atque late aperto. Semicellulae a fronte visae cyathiformes, verruca parva emarginata utroque in latere inflationis basalis, altera altiore in margine ventrali praeditae; pars corporis superior late expansa, angulis lateralibus in duos processus crassos convergentes productis, processibus duos dentes terminales crassos atque dentem minorem in lacuna inter maiores visibilem habentibus, margines ventrales processuum undulati, margines dorsales quoque undulati et duos dentes parvos conicos in unaquaque crista ferentes; apex paululum elevatus, duos dentes intramarginales parvos atque dentem horizontaliter directum utroque in latere ferens. Semicellula a vertice visa subfusiformis, habens margines undulatos retusosque, atque inflationem centralem prominentem utroque in latere, atque extremitates rotundatas, duobus dentibus terminalibus praeditas. Regio centralis apicalis duo paria dentium maiorum atque duo minorum habens; processus duobus ordinibus dentium acutorum parvorum intra marginem praediti.

Cells rather small, width with processes about $1\frac{1}{2}$ times the length, not deeply constricted, sinus small and widely open. In front view semicells cyathiform, with a small emarginate verruca on each side of the basal swelling and another higher on the ventral margin; upper part of body widely expanded and the lateral angles produced into two stout convergent processes with two stout terminal teeth and a smaller one visible in the hollow between the larger teeth; ventral margins of processes undulate, dorsal margins also undulate and bearing two small conical teeth on each crest; apex somewhat elevated and bearing two small intramarginal teeth and a horizontally directed tooth on each side. In vertical view subfusiform with undulate and retuse margins and a prominent central inflation on each side, ends rounded and with two terminal teeth; in the central apical area two pairs of larger and two pairs of smaller teeth, intramarginally on the processes two rows of small sharp teeth. L 35; W base 11, cpr 50; I 8; T 16. Hab. Sumatra 109.

This should be compared with *St. pseudosuecicum* Scott & Presc. (1958).

*Staurastrum tarantulum* sp. nov. Pl. 58, Fig. 8.

Cellulae parvae, cum processibus ca. $1\frac{1}{2}$-plo latiores quam longae, non profunde constrictae, sinu parvo, late aperto. Semicellulae a fronte visae cyathiformes, basibus non inflatis, anulum 12 dentium acutorum parvorum admodum supra infraque isthmum, ca. sex visibilium, atque alium dentem parvum in margine ventrali superiorem sub unoquoque processu habentes; pars superior semicellulae in tres processus tenues curvatos late expansa, processibus primum divergentibus, deinde convergentibus, quattuor dentes terminales habentibus; margines ventrales processuum leves, margines dorsales quattuor vel quinque undulationibus profundis, dente parvo aut verruca emarginata in omni crista, praediti; apex depressus, ferens, autem, aggregationem elevatam verrucarum bifidarum. Semicellula a vertice visa praebens corpus triangulare satis parvum, marginibus convexis, angulis in tres processus attenuatos tenues, quattuor dentibus terminalibus praeditos, productis; margines laterales processuum undulati, dentem parvum in quaque crista, atque par verrucarum bifidarum in undulatione basali maiore, atque ordinem centralem dentium parvorum habentes; regio centralis apicalis per sex verrucas bispinatas, in nonnullis speciminibus ad hexagonum formandum, coniunctas, occupatur.

Cells small, width with processes about $1\frac{1}{2}$ times the length, not deeply constricted, sinus small and widely open. In front view semicells cyathiform, base not inflated, just above and below the isthmus a ring of 12 small teeth, about 6 visible, and another small tooth higher

on the ventral margin under each process; upper part of semicell widely expanded into three slender curved processes, at first divergent then convergent, with four terminal teeth; ventral margins of processes smooth, dorsal margins with four or five deep undulations with a small tooth or emarginate verruca on each crest; apex depressed but bearing an elevated group of bifid verrucae. In vertical view a rather small triangular body with convex margins, the angles produced into three slender tapering processes with four terminal teeth; lateral margins of processes undulate with a small tooth on each crest and a pair of bifid verrucae on the larger basal undulation, also a central row of small teeth; central apical area occupied by a group of six bispinate verrucae which in some specimens are joined to form a hexagon. L 21—27; W cpr 35—40: I 6—7. Hab. Sumatra 110, 114, 115.

*Staurastrum tauphorum* West & West (1902). Formae. Pl. 47, Figs. 1—11.

In addition to the species, West & West (1907) described a fa. *burmense* distinguished by its longer principal processes and smaller basal processes, and Krieger (1933) described var. *sumatranum* in which the principal processes are curved upwardly and lack the large spines on their dorsal margins. The plant is fairly common in several of our Indonesian collections, but it exhibits a good deal of variation in the length and curvature of the principal processes and their spination, and in the size and shape of the small basal processes, with intergrading forms in the same collection, so that we have not been able to find any clear lines of demarcation between the species and these two other forms. Also there is a 4-radiate form not previously known, and others in which the basal processes are not T-shaped but simple hollow spines that may be either pointed or furcate at the end, and these again may occur on the same semicell with T-shaped processes. To separate all these variations would require the creation of several more formae or varieties, but we think this is not justified because of the evidently continuously variable nature of the plant. Accordingly we propose and recommend that the names fa. *burmense* and var. *sumatranum* be deleted. We figure several differing forms of the whole plant, and a number of the forms of the basal processes, but to illustrate all of the combinations would require more space than is available in the present paper. L spr 42—51, cpr 57—68; W cpr 102—138; I 8—10. Hab. Borneo 134, 206—212, 213; Sumatra 106, 115.

*Staurastrum tetracerum* Ralfs (1845). Pl. 57, Fig. 12.
L spr 10—11, cpr 21—24; W cpr 23—24: I 5. Occurs in many collections from Borneo, Java and Sumatra.

*Staurastrum tetracerum* Ralfs var. *trigonum* Lund. (1892). Pl. 57, Fig. 13.
L spr 10, cpr 18; W cpr 18; I 5. Hab. Sumatra 115.

*Staurastrum thienemannii* Krieg. (1933) fa. *triradiatum* fa. nov. Pl. 42, Fig. 5.

Forma quasi eadem magnitudine ac species Differt eo quod semicellula tres processus vice quinque habet, quodque spinae apicales atque unicus dens parvus in margine ventrali basis uniuscuiusque processus minus prominenter effecti sunt.

Size about the same as that of the species. Differs in having only three processes per semicell instead of five, and in the less prominent development of the apical spines and the single small tooth on the ventral margin of the base of each process. L spr 16, cpr 45; W cpr 61; I 9. Hab. Sumatra 149.

*Staurastrum thienemanii* Krieg. (1933) var. *calvum* var. nov. Pl. 42, Fig. 6.

Varietas aliquanto maior quam species. Differt absentia spinarum apicalium atque unici dentis parvi in margine ventrali basis uniuscuiusque processus. In formis et 4- et 5-radiatis reperta est.

Size considerably larger than in the species. Differs in the absence of the apical spines and the single small tooth on the ventral margin of the base of each process. Occurs in both 4- and 5-radiate forms. L spr 20—24, cpr 54; W cpr 71—80; I 12—14. Hab. Sumatra 114, 148, 149.

*Staurastrum tohopekaligense* Wolle (1885) fa. *acuminatum* fa. nov. Pl. 48, Fig. 3.

Forma differens eo quod processus ad unicum apicem attenuati, non bifurcati.

Differs in that the processes taper to a single point instead of being bifurcate.
L spr 33, cpr 61; W spr 22, cpr 68; I 15. Hab. Sumatra 148.

This form might perhaps be considered as teratological, because most of the processes show an abrupt bend near the tip, indicating that the other branch of the normal fork has aborted, and because it occurs in company with specimens of the normal bifurcate form. On the other hand, it might indicate a stage in morphological evolution, since many specimens were observed.

*Staurastrum tohopekaligense* Wolle var. *insigne* West & West (1902). Fa. Pl. 47, Figs. 12—15.
L spr 39—45, cpr 84—96; W spr 28—30, cpr 96—120; I 18. Hab. Borneo 134, 108—135—146.

This plant was quite common in the collection Borneo 108—135—146. All specimens had three processes in the lower whorl and six in the upper, while var. *insigne* from Ceylon has nine in each whorl. However, West & West (1902, pp. 180—181) consider that this difference in number of processes falls within the limits of variation of the species.

*Staurastrum tohopekaligense* Wolle fa. *minus* (Turn.) Scott & Presc. comb. nov. Pl. 48, Figs. 4—6.

Syn. *St. nonanum* Turn. fa. *minor* Turn. (1892).

L spr 22—30, cpr 36—45; W spr 18—21, cpr 33—42; I 10—13. Hab. Java Z; Sumatra 109, 110, 114, 148, 149.

We illustrate two different forms, one with three processes in the lower whorl and six in the upper, the other with nine in the lower whorl and six in the upper, also a Janus-form combining the two types. As noted above, West & West consider that such differences are within the limits of variation of the species, and that is why they rejected (1902, P. 180) Schmidle's suggestion that *St. nonanum* Turn. be placed as var. *nonanum* of *St. tohopekaligense*. The present plant is so much smaller than other described forms or varieties that we consider its separation as a distinct *forma* is justified.

*Staurastrum tohopekaligense* Wolle var. *robustum* var. nov. Pl. 48, Fig. 1.

Varietas magnitudine similis speciei, differens tantummodo quod multo crassior.

Size within the range of the species; differs only in the much stouter habit. L spr 36, cpr 60; W cpr 63; I 18. Hab. Java T.

This plant should be compared with *St. furcatum* var. *cercophorum* Skuja (1949), which has bifurcate processes and is only one-half the size of our plant.

*Staurastrum tohopekaligense* Wolle var. *trifurcatum* West & West (1895). Pl. 48, Fig. 2.

L spr 39, cpr 75; W spr 29, cpr 90; I 18. Hab. Borneo 38.

*Staurastrum triforcipatum* West & West (1902). Pl. 53, Fig. 6.

L to depressed apex 18, cpr ca. 30; W cpr 55; I 7. Hab. Borneo H.

*Staurastrum tripyrenoideum* sp. nov. Pl. 49, Fig. 6.

Cellulae satis magnae, sine spinis paululo latiores quam longae; profunde constrictae, isthmo angusto, sinu late aperto. Semicellula a fronte visa subtriangulare, marginibus ventralibus dorsalibusque quasi aeque convexis, angulis lateralibus spina brevi recurvata deorsum

eminente praeditis. Semicellulae a vertice visae triangulares, spinam brevem ad unumquemque angulum habentes, marginibus lateralibus in media parte retusis, prope angulos paululum convexis. Membrana levis. Chloroplastus in tribus laminis parietalibus unaquaque uno pyrenoidea praedita, divisus.

Cells rather large, width without spines a little greater than the length, deeply constricted, isthmus narrow, sinus widely open. In front view semicells subtriangular, ventral and dorsal margins about equally convex, lateral angles provided with a short, recurved, downwardly projecting spine. In vertical view triangular with a short spine at each angle; lateral margins retuse in the center, slightly convex near the angles. Wall smooth. Chloroplast in three parietal plates each with one pyrenoid. L 57—63; W ssp 66—69, csp 90; I 12—14. Hab. Sumatra 148.

We have not been able to find any other species to which this plant could be referred. The chloroplast, especially, is unusual, and does not correspond with any of the types shown by Teiling (1952) for triangular desmids.

*Staurastrum trissacanthum* sp. nov. Pl. 54, Fig. 7.

Cellulae parvae, latiores ca. triente quam longae (cum spinis), profunde constrictae, sinu late aperto. Semicellulae a fronte visae trapezoideae, unoquoque angulo laterali tribus spinis longis tenuissimisque ad duas altitudines praedito, unica spina inferiore primum paululo ascendente, deinde horizontaliter aut saepius deorsum abrupte deflexa, ambabus spinis superioribus ad basim inflatis, sursum directis; apex fere planus. Semicellulae a vertice visae triangulares, marginibus in media parte retusis, prope angulos convexis, habentes ad unumquemque angulum unicam spinam longam, atque paululum intra unumquemque angulum par spinarum breviorum divergentium habentium bases inflatas quarum margo exterior in marginem semicellulae mergitur. Membrana levis.

Cells small, about one-third wider than long (with spines), deeply constricted, sinus widely open. In front view semicells trapezoidal, each lateral angle provided with three long and very slender spines at two different levels, the single lower spine at first rising slightly and then abruptly bent to a horizontal or more commonly a downwardly directed position, the upper pair of spines with inflated bases and upwardly directed; apex nearly flat. In vertical view triangular with margins slightly retuse in the center and convex near the angles, at each angle a single long spine, and a short distance within each angle a pair of shorter divergent spines with inflated bases whose outer margin merges into that of the semicell. Wall smooth. L ssp 19—21, csp 33—34; W csp 42—44; I 7—8. Hab. Sumatra 110, 114, 148.

This plant shows a resemblance to some others, *e.g. St. trifidum* Nordst., and *St. contectum* var. *aviceps* Krieg. (1933), but we have not been able to reconcile it completely with either of them, and particularly because of the two forms next to be described.

*Staurastrum trissacanthum* nob. fa. *brachyacanthum* fa. nov. Pl. 54, Figs. 8, 9.

Forma a specie differens tantummodo eo quod spinas breviores habet.

Differs only in the shorter length of the spines. L ssp 24, csp 30; W csp 36—38; I 10. Hab. Sumatra 109, 115.

*Staurastrum trissacanthum* nob. var. *dissacanthum* var. nov. Pl. 54, Fig. 10.

Varietas a specie differens tantummodo eo quod duas spinas vice trium ad unumquemque angulum habet.

Differs from the species only in having two spines at each angle instead of three. L ssp 21, csp 39; W csp 42; I 6. Hab. Borneo 108—135—146.

This shows a considerable resemblance to *St. botanense* Playf., but seems to be connected to our species through the dichotypical specimen shown in our Fig. 9.

*Staurastrum trissacanthum* nob. var. *dissacanthum* nob. fa. *brevispinum* fa. nov. Pl. 54, Fig. 11.

Forma a varietate *dissacantho* differens tantummodo eo quod spinas breviores atque isthmum aliquantum latiorem habet.

Differs from var. *dissacanthum* only in the shorter spines and the somewhat wider isthmus. L ssp 25, csp 33; W ssp 25, csp 35; I 10. Hab. Sumatra 109.

*Staurastrum unicorne* Turn. var. *ecorne* (Turn.) West & West (1902) fa. *retusum* fa. nov. Pl. 53, Figs. 3, 4.

*Staurastrum* differens tantummodo forma marginum lateralium retusorum a vertice visorum, non convexorum ut in specie ac in varietate *ecorni*.

Differs only in the shape of the margins in vertical view, which are retuse instead of convex as in the species and var. *ecorne*. L 20—27; W max. 22—31; I 6—7.5. Hab. Sumatra 101, 108, 147.

Both triangular and quadrangular forms have been seen, all with the retuse margins. Many specimens display about six small mucus threads protruding from a ring of pores in the bulbous ends of the processes.

*Staurastrum vaasii* sp. nov. Pl. 51, Fig. 1.

Cellulae satis magnae, cum processibus ca. $1\frac{1}{2}$-plo latiores quam longae, paululum constrictae, sinu parvo, late aperto. Semicellulae a fronte visae subtrapezoideae, marginibus ventralibus undulatis, omnibus undulationibus spinam acutam parvam ferentibus; anguli laterales in processus perlongos tenues sursum curvatos, quattuor spinis terminalibus longis praeditos, producti; marginibus ventralibus processuum in dimidio proximali serratis, atque in dimidio distali dentatis, marginibus dorsalibus in trientebus proximalibus distalibusque dentatis atque alibi serratis; apex horizontalis, 6-undulatus, omnibus undulationibus dentem brevem aut verrucam bidentatem ferentibus; superficies semicellulae ca. octo dentes parvos in parte superiore irregulariter dispositos, atque interdum in parte inferiore duos dentes maiores praebens. Semicellula a vertice visa corpus subellipticum, marginibus undulatis, habens, omnibus undulationibus dente acuto parvo praeditis, habens necnon polos in processus perlongos tenuesque productos, processibus margines inconspicue serratos atque quattuor dentes terminales magnos atque ordinem medium parvorum, in media parte longitudinis interruptum, praebentibus; superficies apicalis ordinem intramarginalem dentium minimorum utroque in latere atque ordinem alterum interiorem dentium maiorum aut verrucarum bidentatarum habens.

Cells rather large, width about $1\frac{1}{2}$ times the length with processes, slightly constricted, sinus small and widely open. In front view semicells subtrapezoidal with undulate ventral margins, each undulation bearing a small sharp spine; lateral angles produced into very long, slender, upwardly curved processes with four long terminal spines; ventral margins of processes serrate on the proximal half and dentate on the distal half, dorsal margins dentate on the proximal and distal thirds and serrate between; apex horizontal and 6-undulate, each undulation bearing a short tooth or a bidentate verruca; face of semicell with about eight small teeth irregularly disposed on the upper and sometimes two larger teeth on the lower part. In vertical view a small subelliptical body with undulate margins, each undulation with a small sharp tooth, the poles prolonged into very long slender processes with faintly serrate margins and four large terminal teeth, and a median row of small teeth that is interrupted in the central part of the length; on the apical surface an intramarginal row of very small teeth on each side and another inner row of larger teeth or bidentate verrucae. L spr 33, cpr 73; W cpr 117; I 8; T 15. Hab. Borneo 134, 108—135—146.

This plant may be compared with *St. alandicum* fa. *gracile* Thomasson (1955), and *St. guentheri* Thomasson (1956).

*Staurastrum vaasii* nob. var. *nudum* var. nov. Pl. 51, Fig. 2.

Cellulae sine processibus breviores ca. quadrante quam cellulae speciei, cum processibus quasi eadem longitudine latitudineque. Semicellulae a fronte visae subtriangulares inflationem prominentem in unoquoque margine ventrali habentes, dentibus, autem, in marginibus superficieque carentibus, angulis lateralibus in processus perlongos tenues sursum divergentes et paululum curvatos extensis, processibus tres dentes terminales vice quattuor atque levissimos margines ventrales dorsalesque habentibus; apex horizontalis, duabus undulationibus parvis praeditus. Semicellulae a vertice visae corpus fusiforme parvum habentes, polis in processus perlonges tenues rectosque productis, processibus tres dentes terminales atque margines leves habentibus; regio apicalis levis, ornatum nullum aut fortasse duos dentes minutos in parte centrali praebens.

Length of cells without processes about one-quarter less than that of the species, length and width with processes about the same. In front view semicells subtriangular, with a prominent swelling on each ventral margin but no teeth either on the margins or on the face, lateral angles extended into very long slender processes with three terminal teeth instead of four and perfectly smooth ventral and dorsal margins, processes upwardly divergent and slightly curved; apex horizontal and with two slight undulations. In vertical view a small fusiform body with the poles produced into very long, slender, straight processes with three terminal teeth and smooth margins; apical area smooth with no ornament, or perhaps with two minute teeth in the central part. L spr 24—26, cpr 72—83; W cpr 87—112; I 7—8; T 11—12. Hab. Borneo 134, 108—135—146, 206—212.

This plant occurs in two of the collections that contain the species, so that the two forms can easily be compared. We have not seen any intermediate or connecting forms, so it is not certain that this one really is a variety of the species, but for the present it is convenient so to describe it. It should be compared with *St. quadrinotatum* Grönbl. (1945) which is similar but different.

*Staurastrum vestitum* Ralfs (1848) var. *gymnocephalum* var. nov. Pl. 58, Fig. 9.

Varietas a specie differens quod minor quodque processus breviores atque nullas verrucas apicales habet. Aliae proprietates quasi eadem atque in specie.

Size smaller than in the species, and with shorter processes. Differs in the absence of all apical verrucae, the other characteristics about the same as in the species. L 21; W cpr 32; I 7. Hab. Java 505.

*Staurastrum woltereckii* Behre (1956). Fa. Pl. 60, Fig. 1.
L 25; W cpr 33; I 6. Hab. Java 505.

Similar to the species, but with shorter processes that are almost horizontal.

*Staurastrum wildemanii* Gutw. (1902). Pl. 49, Fig. 1.
L ssp 50—60, csp 54—87; W ssp 47—63, csp 70—124; I 24—25. Hab. Borneo 38; Java T; Sumatra 109, 114; and many others throughout the region.

*Staurastrum wildemanii* Gutw. var. *horizontale* Scott & Presc. (1956a). Pl. 49, Fig. 3. L 45—48; W ssp ca. 42, csp 99—117; I 18—20. Hab. Borneo X; Sumatra 110, 111, 112.

*Staurastrum wildemanii* Gutw. var. *majus* (West & West) Scott & Presc. (1956a). Pl. 49, Fig. 2.
L ssp 50—66, csp 60—76; W ssp 48—63, csp 72—117; I 21—24. Hab. Borneo 38; Sumatra 109, 111, 112.

*Staurastrum wildemanii* Gutw. var. *unispiniferum* Scott & Presc. (1956a). Pl. 49, Fig. 4.
L 50—54; W ssp ca. 51, csp 98—102; I 18—21. Hab. Sumatra 108, 112.

*Staurastrum xanthium* Krieg. (1933). Pl. 58, Fig. 10.
L ssp 28—30, csp 45—54; W ssp 33—38, csp 45—57; I 10—12. Hab. Borneo X; Java O, T.

*Staurastrum zahlbruckneri* Lütkem. var. *mamillatum* West & West (1901). Pl. 44, Fig. 8.
L 102—110; W 84—93; I 33—36. Hab. Java 504, 505; Sumatra 104.

*Staurastrum zonatum* Börges. var. *ceylanicum* West & West (1902). Pl. 48, Fig. 9. Pl. 59, Fig. 2.
L spr 39, cpr 54; W cpr 57; I 12. Hab. Sumatra 108, 114, 148, 149.

This occurs in both 5- and 6-radiate forms, and two Janus specimens were seen with five processes on one semicell and six on the other.

*Staurastrum zonatum* Börges. (1880) var. *majus* var. nov. Pl. 46, Fig. 8. Pl. 48, Figs. 7, 8.

Varietas maior quam species et processus multo longiores habens. Semicellulae a fronte visae magis cyathiformes atque ad fastigium proportione latiores; processus multo longiores, ad extremitates 5-dentati, anulis pluribus granulorum praediti; apex biundulatis, nonnullis dentibus parvis visibilibus. Semicellulae a vertice visae 4-, 5-

vel 6-radiatae, marginibus lateralibus corporis undulatis, unoquoque duas verrucas emarginatas parvas habente; regio apicali duo paria dentium conicorum parvorum unicuique intramarginaliter opposita praebens.

Larger than the species and with much longer processes. In front view differs in the shape of the semicells which are more cyathiform and proportionately wider at the top; processes much longer, 5-dentate at the ends, and with more rings of granules; apex biundulate with some small teeth visible. In vertical view 4-, 5- or 6-radiate, lateral margins of the body undulate and with two small emarginate verrucae on each undulation; apical area with two pairs of small conical teeth intramarginally opposite each side. L spr 39—45, cpr 54—60; W cpr diag. 79—93; I 14—15. Hab. Borneo 134, 206—212; Sumatra 111.

The commonest form is 4-radiate; a few are 5-radiate; two Janus specimens were seen with four processes on one semicell and five on the other; and only one had six processes on each semicell.

## SPHAEROZOSMA Corda 1834

*Sphaerozosma granulatum* Roy & Biss. (1886). Pl. 60, Fig. 5.
L 12—13; W 13—17; I 6—7; T 7—8. Hab. Sumatra 110, 147, 148.

## SPONDYLOSIUM Brébisson 1844

*Spondylosium moniliforme* Lund. (1871). Pl. 60, Fig. 11.
L 23; W 18; I 9. Hab. Sumatra 115.

*Spondylosium nitens* (Wall.) Arch. fa. *majus* Turn. (1892). Pl. 60, Fig. 9.
L 21—24; W 30—32; I 6; T 10—11. Hab. Sumatra 148.

This plant was very rare, only two short twisted filaments having been seen in the numerous temporary mounts made from this very rich collection. One filament, shown in our figure, exhibited a curious phenomenon in regard to the isthmus, which varied from extremely short with an acute sinus to abnormally long, almost as long as an entire normal cell, and with a rectangular sinus. The chloroplasts were much deteriorated, but this was in one way an advantage, because it enabled us to observe the cross-walls shown in our figure, which prove that the supposed elongated isthmus described and illustrated by TURNER (1892), and by THOMASSON (1957) from Lake Bangweulu in Northern Rhodesia, actually consists of the two new semicells which apparently develop as cylindrical tubes with truncate ends until they reach almost their full length, after which the lateral

lobes must develop, though this last step was not observed. The name, fa. *tensa* Turner must therefore be deleted.

*Spondylosium nitens* (Wall.) Arch. var. *triangulare* Turn. fa. *javanicum* Gutw. (1902). Pl. 60, Fig. 10.
L 26—31; W 25—28; I 7—8. Hab. Borneo 403; Sumatra 102, 110, 148.

GUTWINSKI gives the length as 28.6; width 14—16, but this proportion does not agree with his figure, in which the width and length are about equal. Apparently the only difference between fa. *javanicum* and the typical variety is its rounded apex as compared with the truncate apex as figured by TURNER. Whether such a flat apex with sharp angles really exists seems doubtful to us; we have never seen it in any desmid.

*Spondylosium planum* (Wolle) West & West (1912). Pl. 60, Figs. 6—8.
L 11—14; W 11—18; I 5—6; I 8.5—9. Hab. Java M & P; Sum. 148.

## ONYCHONEMA Wallich 1860

*Onychonema laeve* Nordst. (1870) var. *constrictum* var. nov. Pl. 60, Fig. 12.

Varietas differens in isthmo elongato, indentationem minutam parte in media habente.

Differs in the elongated isthmus which has a minute indentation at its center.
L 18—20; W ssp 23—26, csp 27—32; I 5; T 9. Hab. Sumatra 101, 148, 149.

This should be compared with var. *oscitans* Scott & Presc. (1958) from Arnhem Land. In that paper we stated that var. *oscitans* had also been found in Sumatran material, but this was a mistake; what we had in mind was var. *constrictum* which differs because of the elongated and indented isthmus.

*Onychonema laeve* Nordst. var. *latum* West & West (1896). Pl. 60, Fig. 13.
L 18; W ssp 24, csp 34; I 4.5; T 9. Hab. Sumatra 108, 111, 149.

*Onychonema laeve* Nordst. var. *micracanthum* Nordst. (1880). Pl. 60, Fig. 14.
L 15; W csp 20; I 4.5. Hab. Borneo 38; Sumatra 114.

*Onychonema* Nordst. (1870) var. *sumatranum* var. nov. Pl. 61, Fig. 1.

Varietas forma var. *lato* similis, differens, autem, latitudine maiore, possessione duarum eminentiarum apicalium vice unius, praecipue necnon modo proprio divisionis cellulae.

Similar in shape to var. *latum*. Differs in its greater width, the possession of two apical eminences instead of one, and especially in the peculiar method of cell division. L 18—21; W ssp 32—34, csp 42; I 6—7; T 9—11. Hab. Sumatra 148.

Several filaments were seen, usually twisted about 90° in the length of about 12 cells. One filament, shown in our figure, has several cells in the process of division, and in one cell the two new semicells are seen to have separate chloroplasts with the cross-wall faintly visible. From this appears that the new semicells reach almost their full width before division and before the development of the convex apex with its processes.

## HYALOTHECA Ehrenberg 1841

*Hyalotheca dissiliens* (Smith) Bréb. var. *hians* Wolle (1885). Pl. 61, Fig. 2.
L 15; W max. 15; W apex 12. Hab. Java M & P.

*Hyalotheca mucosa* (Dillw.) Ehrbg. (1841). Not illustrated.
L 20; W 18. Hab. Java 505.

*Hyalotheca undulata* Nordst. (1879). Pl. 61, Fig. 3.
L 10; W 6.5; I 5. Hab. Sumatra 114, 148.

*Hyalotheca undulata* Nordst. var. *perundulata* Grönbl. (1938). Pl. 61, Fig. 4.
L 18—20; W 5.5—6.5; I 4—4.5. Hab. Sumatra 114, 148, 149.

## GROENBLADIA Teiling 1952

*Groenbladia inflata* Scott & Grönbl. (1957). Pl. 61, Figs. 5, 6.
L 42; W max. 12; W pole 9; I 10. Zygospore tetrahedral, maximum side about 27. Hab. Sumatra 114.

Cells a little shorter than the American type, otherwise in agreement and with the same kind of zygospore. It seems quite remarkable that this new species should have been discovered in such far distant places as Louisiana and Florida, U.S.A., and Sumatra, by the same man (Scott), and at an interval of only a few years.

*Groenbladia neglecta* (Racib.) Teiling (1952). Pl. 61, Fig. 7.
L 34—39; W max. 13; W pole 11; I 12. Hab. Sumatra 114.

*Groenbladia neglecta* (Racib.) var. *elongata* Scott & Grönbl. (1957). Pl. 61, Fig. 8.
L 40—44; W center 9—11; W pole 7.5—8. Hab. Borneo 404.

This is another instance of almost simultaneous discovery by Scott in Louisiana and Florida, and in Borneo.

## PHYMATODOCIS Nordstedt 1877

*Phymatodocis irregularis* Schm. var. *intermedia* Gutw. (1902). Pl. 61, Figs. 11—15.
L 28—30; W max. 51—63; I 24—28. Hab. Java M & P; Sumatra 110, 112, 147.

Gutwinski (1902, Pl. 36, Fig. 4e) illustrated „zygotes" formed between the separated halves of several adjacent cells of a filament. We found two short filaments like this, with all cells in about the same stage, of which we give a figure that is quite similar to Gutwinski's. The phenomenon is rather puzzling, for zygospores cannot be formed between the halves of a single cell, but after careful study of the two specimens we have reached the conclusion that it is simply a stage in vegetative division before the formation of the cross-wall. This may be confirmed at some future date if specimens in other stages of the process are observed. As Gutwinski noted, the older semicells are brown and closely punctate (porose), younger ones colorless.

*Phymatodocis nordstedtiana* Wolle (1884). Pl. 61, Figs. 9, 10.
L 46—47; W square 39—41, diag. 45—47; I 24. Hab. Borneo 38A.

In this species also the wall is golden-brown and closely punctate (porose). In southeastern U.S.A. the plant is fairly common, and American specimens could hardly be distinguished from those from Borneo if the two were placed side by side.

## BAMBUSINA Kutzing 1845.

*Bambusina brebissonii* Kütz. (1845). Pl. 62, Fig. 1.
Syn. *Bambusina borreri* (Ralfs) Cleve (1864).
*Gymnozyga moniliformis* Ehrbg. (1841).
L 36; W max. 26; W pole 17. Hab. Sumatra 114, and many other collections from Java, Sumatra and Borneo.

According to the 1956 edition of the International Code of Botanical Nomenclature *Bambusina* is the *nomen conservandum*, of which *B. brebissonii* is the type.

*Bambusina brebissonii* Kütz. var. *gracilescens* (Nordst.) Wolle (1884). Pl. 62, Fig. 4.

Syn. *B. borreri* (Ralfs) Cleve var. *gracilescens* Nordst. (1880). L 28; W max. 15; W pole 8. Hab. Sumatra 114.

*Bambusina brebissonii* Kütz. fa. *constricta* fa. nov. Pl. 62, Figs. 2, 3.

Varietas quasi eadem magnitudine ac species; differens constrictione maiore ad partem mediam inter inflationem centralem atque polum, ita ut polus inflatus apparest.

Size about the same as in the species. Differs in the greater constriction midway between the central swelling and the pole, causing the latter to appear inflated. L 36; W max. 25; W min. ca. 22; W pole 15. Hab. Sumatra 149.

The pole is no wider than usual, though it appears so because of the greater constriction. The striae visible in front view appear as minute and irregular crenulations in the end view; they represent plications in the wall that are caused, we believe, by circumferential compression during extrusion of the end section.

## DESMIDIUM C. A. Agardh 1824.

*Desmidium aptogonum* Bréb. var. *tetragonum* West & West (1902). Pl. 62, Figs. 5—7.
L 18; W square 25, diag. 31; I 14. Hab. Borneo 38; Java M & P; Sumatra 148.

*Desmidium baileyi* (Ralfs) Nordst. fa. *tetragonum* Nordst. (1888). Pl. 62, Figs. 8, 9.
L 16—17; W square 20—21, diag. 25—26. Hab. Borneo 38; Java M & P; Sumatra 114.

Lateral margin of cell with two minute undulations. Filaments not twisted. Zygospore elliptical.

*Desmidium baileyi* (Ralfs) Nordst. fa. *longiprocessum* fa. nov. Pl. 62, Figs. 10, 11.

Forma quasi eadem magnitudine ac species; a vertice visa quadrangularis; differens eo quod processus apicales multo longiores, indentationem parvam ad locum eversionis praebentes, habet.

Size about the same as in the species; vertical view quadrangular. Differs in the much longer apical processes, which show a slight indentation at the point of eversion. L cpr 16; W square 21, diag. 25. Hab. Sumatra 147.

*Desmidium bengalicum* Turn. (1892). Pl. 62, Figs. 12, 13.
L 27; W 36—38; I 21. Hab. Sumatra 114, 148.

The dimensions are considerably larger than those given by TURNER.

*Desmidium bengalicum* Turn. fa. *quadratum* fa. nov. Pl. 62, Fig. 14.

Forma differens tantummodo eo quod a vertice visa quadrangularis non triangularis.

Differs only in being quadrangular in vertical view instead of triangular.

L 27; W square 28, diag. 37; I 21. Hab. Sumatra 114.

*Desmidium graciliceps* (Nordst.) Lagerh. (1886). Pl. 63, Figs. 1—4.
L 42; W max. 33—36, min. 18—20, apex 12—14; I 22. Zygospore L 40; W 36. Hab. Sumatra 110, 114.

In side view the cells seem somewhat thinner than usual. The zygospore corresponds with that figured by LAGERHEIM (1886); it is formed in a conjugation tube between the empty and dissociated gametangial cells.

*Desmidium grevillei* (Kütz.) De Bary (1858). Fa. Pl. 62, Figs. 15, 16.
L 31; W max. 40—42, min. 31, pole 18—20. Hab. Borneo 38A; Java 505.

*Desmidium quadratum* Nordst. (1873). Pl. 63, Figs. 5, 6.
L 19—24; W max. 30—36, min. 27—29, pole 26—33. Hab. Borneo 38, 402; Sumatra 147, 149.

*Desmidium suboccidentale* Scott & Presc. (1958). Pl. 63, Fig. 7.
L 15—16; W 27—30; I 20—22. Hab. Java P, M & P; Sumatra 148.

*Desmidium swartzii* Agardh (1824). Pl. 63, Fig. 8.
L 15—16; W 43—45; I 36. Hab. Borneo 403; Sumatra 147.

*Desmidium swartzii* Agardh var. *bicristatum* var. nov. Pl. 63, Fig. 9.

Varietas magnitudine formaque varietati *amblyodo* (Itz.) Rab. similis, differens, autem, eo quod habet cristam manifestam, ut duas lineas parallelas curvatasque partem latissimum utriusque semicellulae complexas visam.

Similar in size and shape to var. *amblyodon* (Itz.) Rab., but differs in that there is a distinct ridge, seen as two parallel curved lines, running circumferentially around each semicell at its widest part.
L 21; W 46; I 40. Hab. Java M & P.

This is similar to the form illustrated in our Arnhem Land paper (1958, Pl. 21, Fig. 13), though the Australian plant has sharp angles on each side of the isthmus and thus resembles the species rather than var. *amblyodon*.

## STREPTONEMA Wallich 1860.

*Streptonema trilobatum* Wallich (1860). Pl. 63, Figs. 10—16.
L 20—30; W 45—51; I 14—55. Hab. Java O, M & P; Sum. 108, 148.

There is some variation in the vertical view of the cells, as shown in our figures, but practically all of them are asymmetric, with the lobules twisted in a counterclockwise direction. Our rear view, Fig. 11, shows two new semicells in contact, with the apical pads developing as infoldings of the wall and without the mucus connectors, while in the older semicells the pads are everted and the mucus connectors are fully developed. Unfortunately specimens in the division stage are quite rare and this is the only one of which we have been able to make a good drawing. Many filaments are infested with a minute epiphytic alga that grows in the interspaces and makes observation difficult or impossible. There are four pyrenoids in each semicell, one centered above the isthmus and one in each of the lobules; the nucleus is situated in the isthmus.

## ADDENDUM

After this paper was set in page form, and too late to make the necessary changes, we received from Japan a reprint of a paper by Taketoshi HINODE, "On some Japanese Desmids (3)", *Hibokia* 2(2), July 1960, in which he describes *Euastrum horikawae* sp. nov. This is evidently the same as *E. prowsei* nob., though our specimens from Borneo are somewhat larger than those from Japan. HINODE's name for the plant has priority, and therefore *E. prowsei* is a synonym for *E. horikawae* Hinode.

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*PLATES*

Plate 1.

1, 2. *Spirotaenia condensata* Bréb. 1 x380, 2 x335.

3. *Cylindrocystis brebissonii* Menegh. x645.

4. *C. crassa* De Bary x740.

5. *Netrium digitus* (Ehrbg.) Itzigs. & Rothe x345.

6. *N. digitus* var. *lamellosum* (Bréb.) Grönbl. x175.

7. *Gonatozygon aculeatum* Hastings x485.

8. *G. brebissonii* De Bary x480.

9, 10. *G. monotaenium* De Bary 9 x480, 10 x140.

11. *Penium cylindrus* (Ehrbg.) Bréb. x655.

12. *P. spirostriolatum* Barker x480.

13. *P. spirostriolatiforme* West & West x340.

14. *Closterium cynthia* De Not. var. *jenneri* (Ralfs) Krieg. x650.

15. *C. venus* Kütz. x480.

16. *C. tumidum* Johnson x340.

17, 18. *C. abruptum* W. West var. *angustissimum* Schm. x360.

19. *C. intermedium* Ralfs x340.

20. *C. calosporum* Wittr. x480.

21. *C. setaceum* Ehrbg. x245.

22. *C. braunii* Reinsch x105.

23. *C. kuetzingii* Bréb. var. *vittatum* Nordst. x205.

24. *C. turgidum* Ehrbg. var. *borgei* (Borge) Defl. x75.

25. *C. ralfsii* Bréb. var. *hybidrum* Rab. x135.

26. *C. lineatum* Ehrbg. Fa. x140.

27, 28. *C. rectimarginatum* sp. nov. x345.

29. *C. lunula* (Müll.) Nitzsch var. *massartii* (Wildem.) Krieg. x105.

30. *C. lunula* var. *massartii* (Wildem). Krieg. fa. *nasutum* fa. nov. x140.

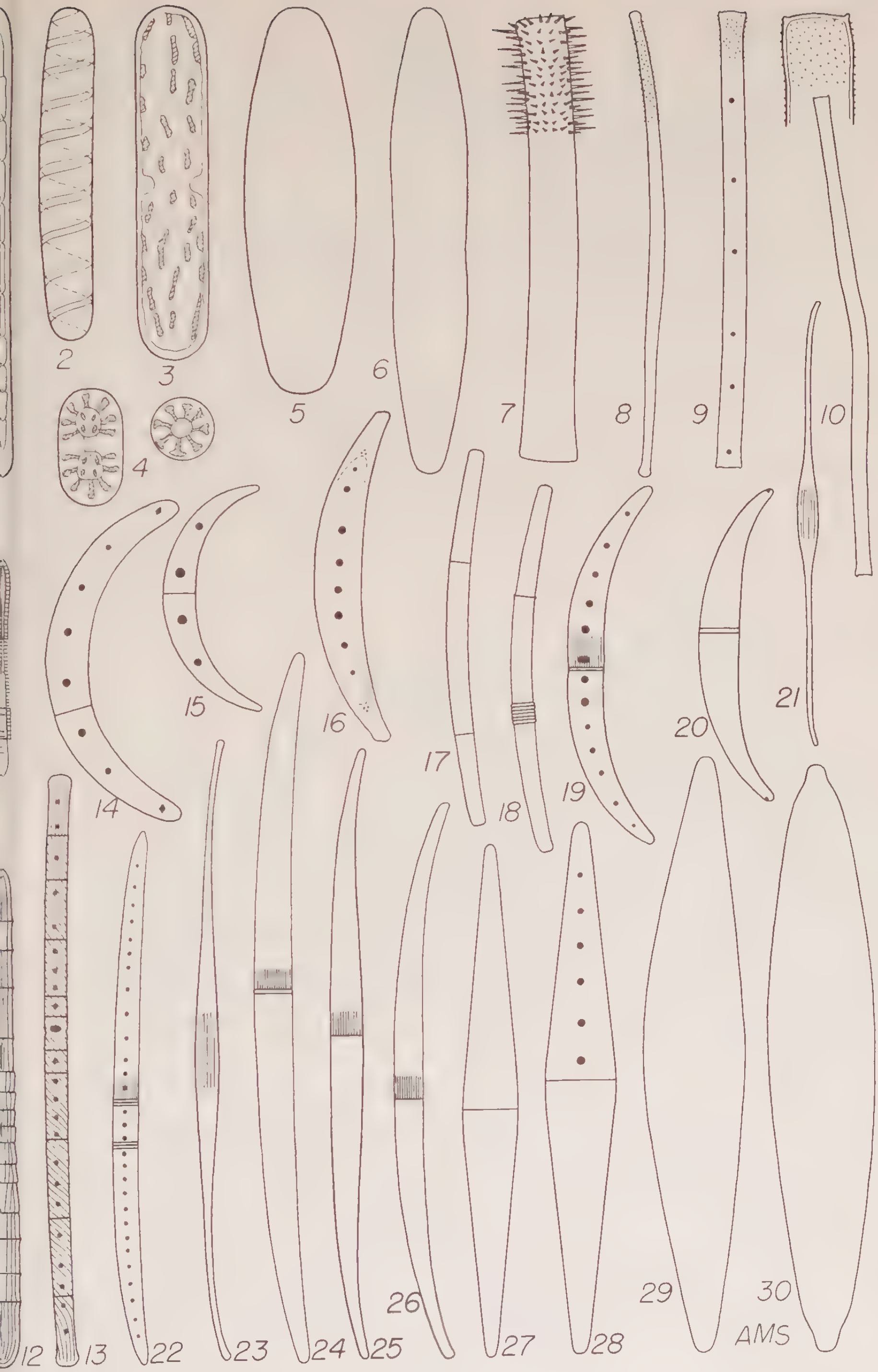
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Plate 1

Plate 2.

1. *Closterium biclavatum* Börges. x240.
2. *C. ehrenbergii* Menegh. x180.
3. *C. nematodes* Josh. x250.
4. *C. nematodes* Josh. Fa. x200.
5. *C. lagoense* Nordst. var. *crassius* Gutw. x340.
6. *C. porrectum* Nordst. x340.
7. *C. dianae* Ehrbg. var. *pseudodianae* (Roy) Krieg. x240.
8. *C. dianae* Ehrbg. var. *minus* (Wille) Schröder x350.
9. *C. parvulum* Näg. var. *cornutum* (Playf.) Krieg. x350.
10. *C. infractum* Messik. x640.
11. *C. validum* West & West x345.
12. *C. cuspidatum* Bail. x350.
13. *C. navicula* (Bréb.) Lütkem. x640.
14. *C. porrectum* Nordst. var. *angustatum* West & West x480.
15. *C. pusillum* Hantzsch x640.
16. *C. gracile* Bréb. x385.
17. *C. gracile* Bréb. var. *striolatum* Krieg. x345.
18. *C. cornu* Ehrbg. var. *javanicum* Gutw. x345.
19. *C. libellula* Focke var. *elongatum* (Krieg.) Scott & Presc. comb. nov. x245.
20. *C. libellula* Focke var. *intermedium* (Roy & Biss.) G.S.West x480.
21. *C. baillyanum* Bréb. x210.
22. *C. striolatum* Ehrbg. x205.
23. *C. striolatum* Ehrbg. var. *subtruncatum* (West & West) Krieg. x360.
24. *Pleurotaenium minutum* (Ralfs) Delp. x480.
25. *P. minutum* (Ralfs) Delp. var. *latum* Krieg. x240.
26. *P. minutum* (Ralfs) Delp. var. *elongatum* (West & West) Cedergren x250.
27. *P. minutum* (Ralfs) Delp. var. *excavatum* Scott & Grönbl. x350.

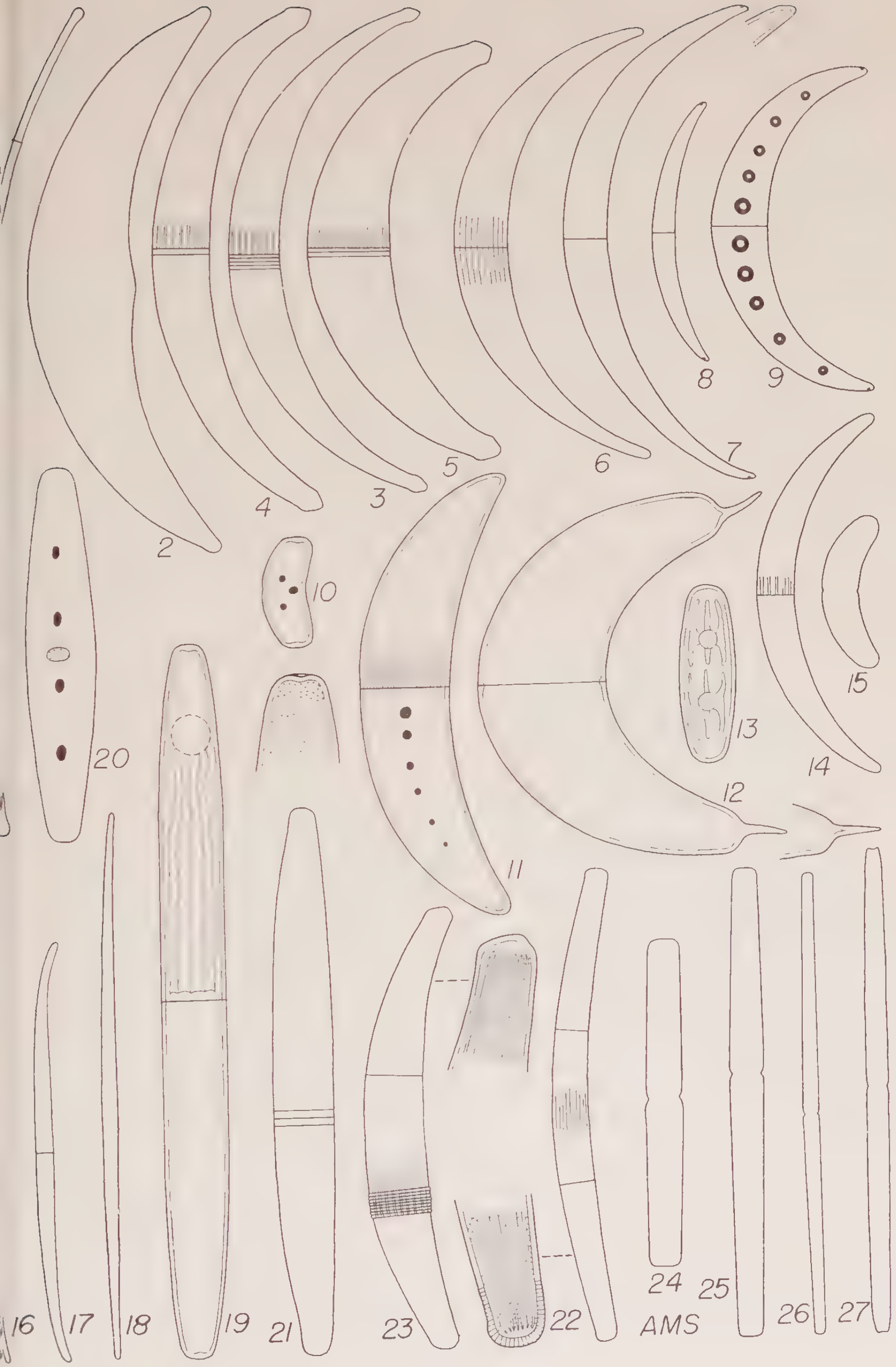


Plate 2

Plate 3.

1. *Closterium acerosum* (Schrank) Ehrbg. x175.
2. *C. acerosum* (Schrank) Ehrbg. fa. *rectum* fa. nov. x128.
3. *Docidium baculum* Bréb. x350.
4. *Pleurotaenium trabecula* (Ehrbg.) Näg. x235.
5. *P. baculoides* (Roy & Biss.) Playf. x250.
6. *P. coronatum* (Bréb.) Rab. var. *fluctuatum* W. West x205.
7. *P. coronatum* (Bréb.) Rab. var. *nodulosum* (Bréb.) W. West x175.
8. *P. truncatum* (Bréb.) Näg. Fa. x260.
9. *P. truncatum* (Bréb.) Näg. var. *farquharsonii* (Roy) West & West x350.
10. *P. simplicissimum* Grönbl. var. *sumatranum* var. nov. x106.
11. *P. trabecula* (Ehrbg.) Näg. var. *maximum* (Reinsch) Roll fa. *constrictum* fa. nov. x205.
12. *P. ehrenbergii* (Bréb.) De Bary var. *undulatum* Schaarschm. x500.
13. *P. simplicissimum* Grönbl. var. *insigne* (Roll) Krieg. x200.
14. *P. ehrenbergii* (Bréb.) De Bary var. *elongatum* (W. West) West & West Fa. x210.
15. *P. tridentulum* (Wolle) W. West var. *fernaldii* Taylor x495.
16. *P. elatum* (Turn.) Borge x180.

17-19. *Euastrum sachlanii* sp. nov., with zygospore x640.

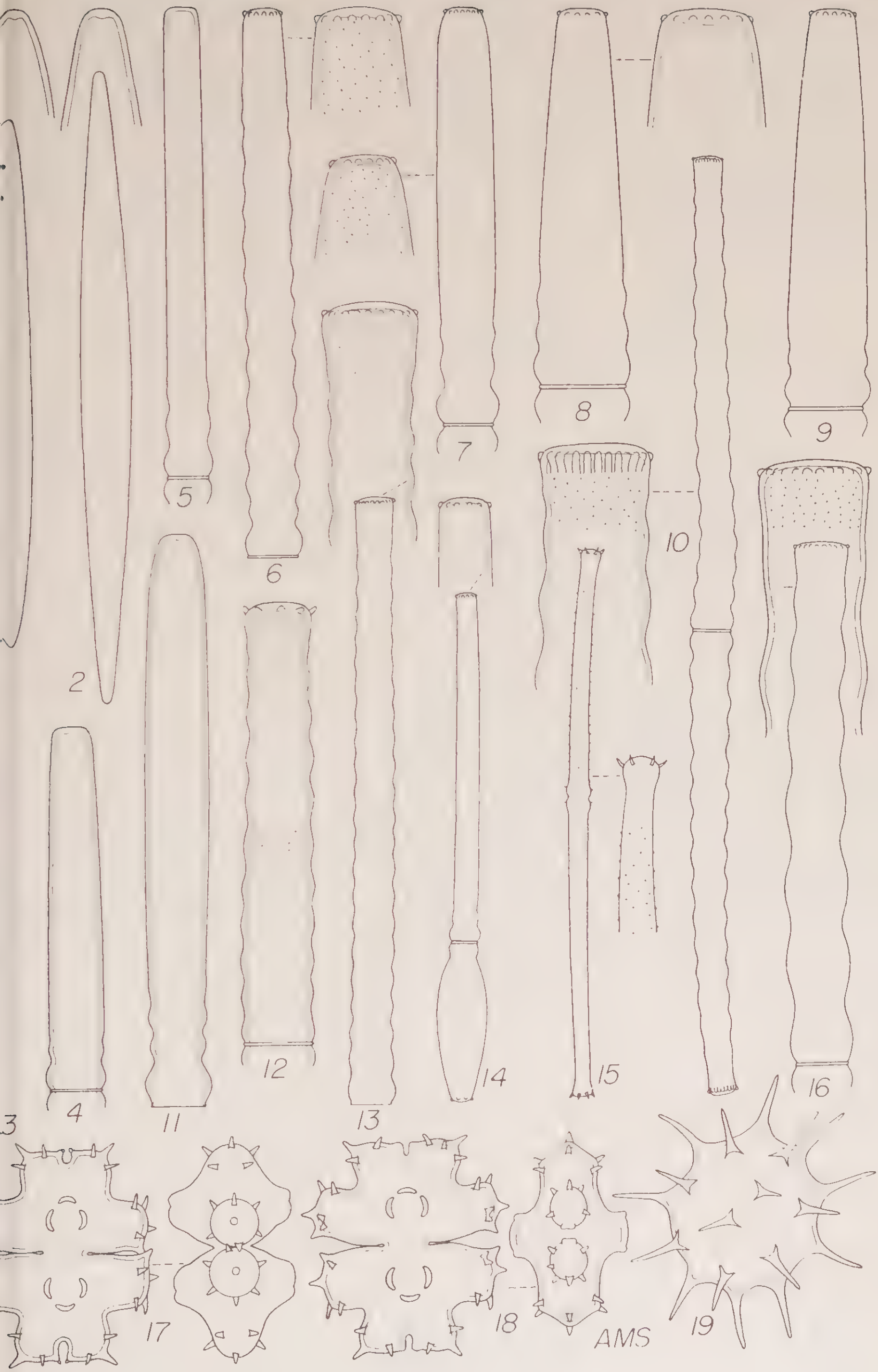


Plate 3

Plate 4.

1, 2. *Pleurotaenium subcoronulatum* (Turn.) West & West Fa. 1 x130, 2 x220.

3. *P. eugeneum* (Turn.) West & West Fa. x280.

4. *P. eugeneum* (Turn.) West & West fa. *constrictum* fa. nov. x250.

5. *P. burmense* (Josh.) Krieg. var. *longissimum* var. nov. x100.

6. *P. undatum* sp. nov. x180.

7. *P. treubii* Bern. x215.

7a. *P. treubii* Bern. Appearance of pores at a high focus.

7b. *P. treubii* Bern. Appearance of pores at a low focus.

7c. *P. treubii* Bern. Probable appearance of pores in optical section, according to KRIEGER.

7d. *P. treubii* Bern. Probable appearance of pores in optical section, according to GRÖNBLAD.

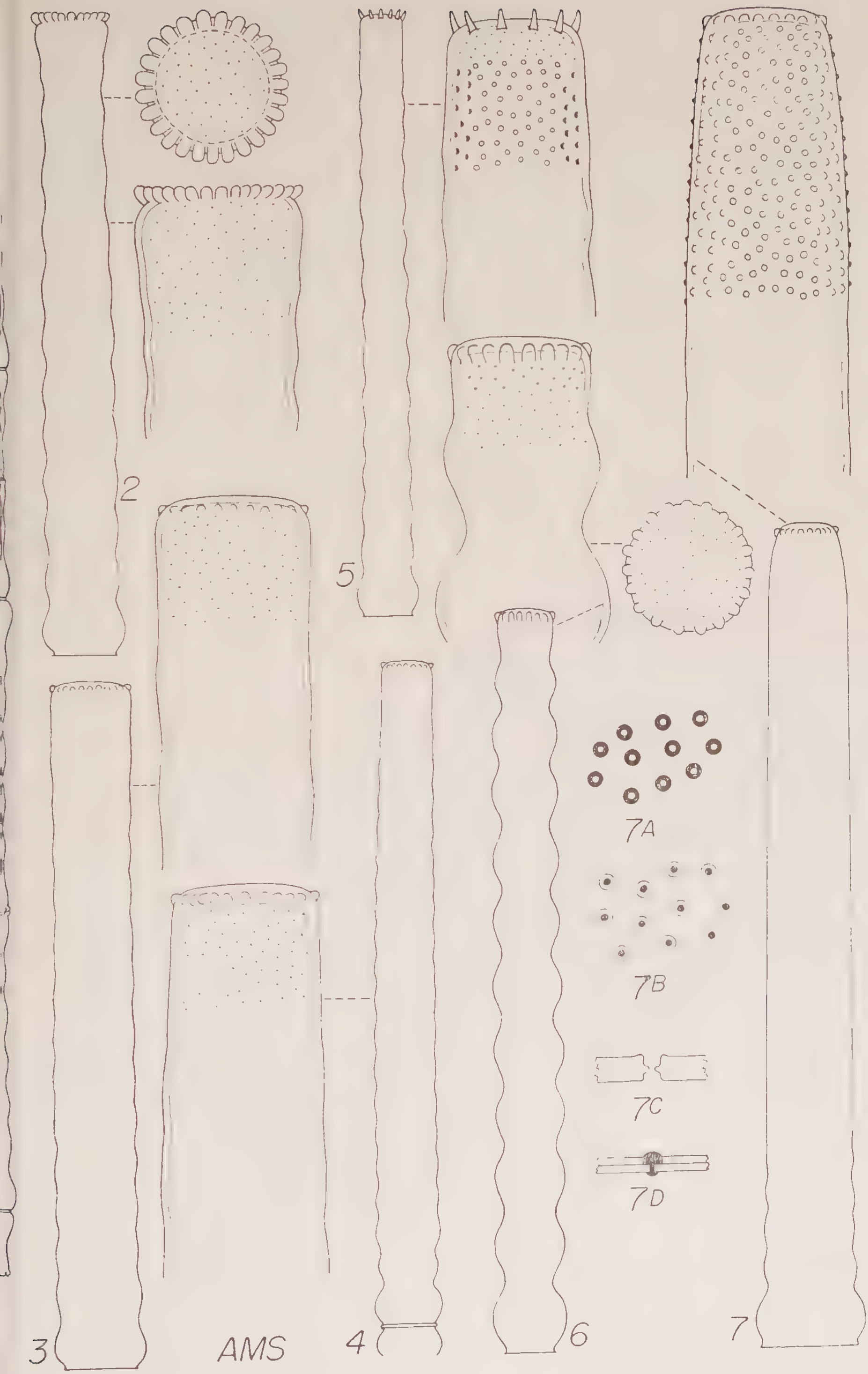


Plate 4

Plate 5.

1. *Pleurotaenium coroniferum* (Borge) Krieg. Fa. x220.

2. *P. coroniferum* (Borge) Krieg. var. *multinodosum* Scott & Presc. x460.

3, 4. *P. nodosum* (Bail.) Lund. Two differing forms. 3 x260, 4 x310.

5. *P. nodosum* (Bail.) Lund. var. *borgei* Grönbl. Fa. x220.

6. *P. nodosum* (Bail.) Lund. var. *gutwinskii* Krieg. x220.

7, 8. *P. verrucosum* (Bail.) Lund. var. *bulbosum* Krieg. Two differing forms. 7 x600, 8 x480.

9. *P. verrucosum* (Bail.) Lund. var. *validum* Scott & Grönbl. x425.

10. *P. kayei* (Arch.) Rab. x310.

11. *P. kayei* (Arch.) Rab. Fa. x320.

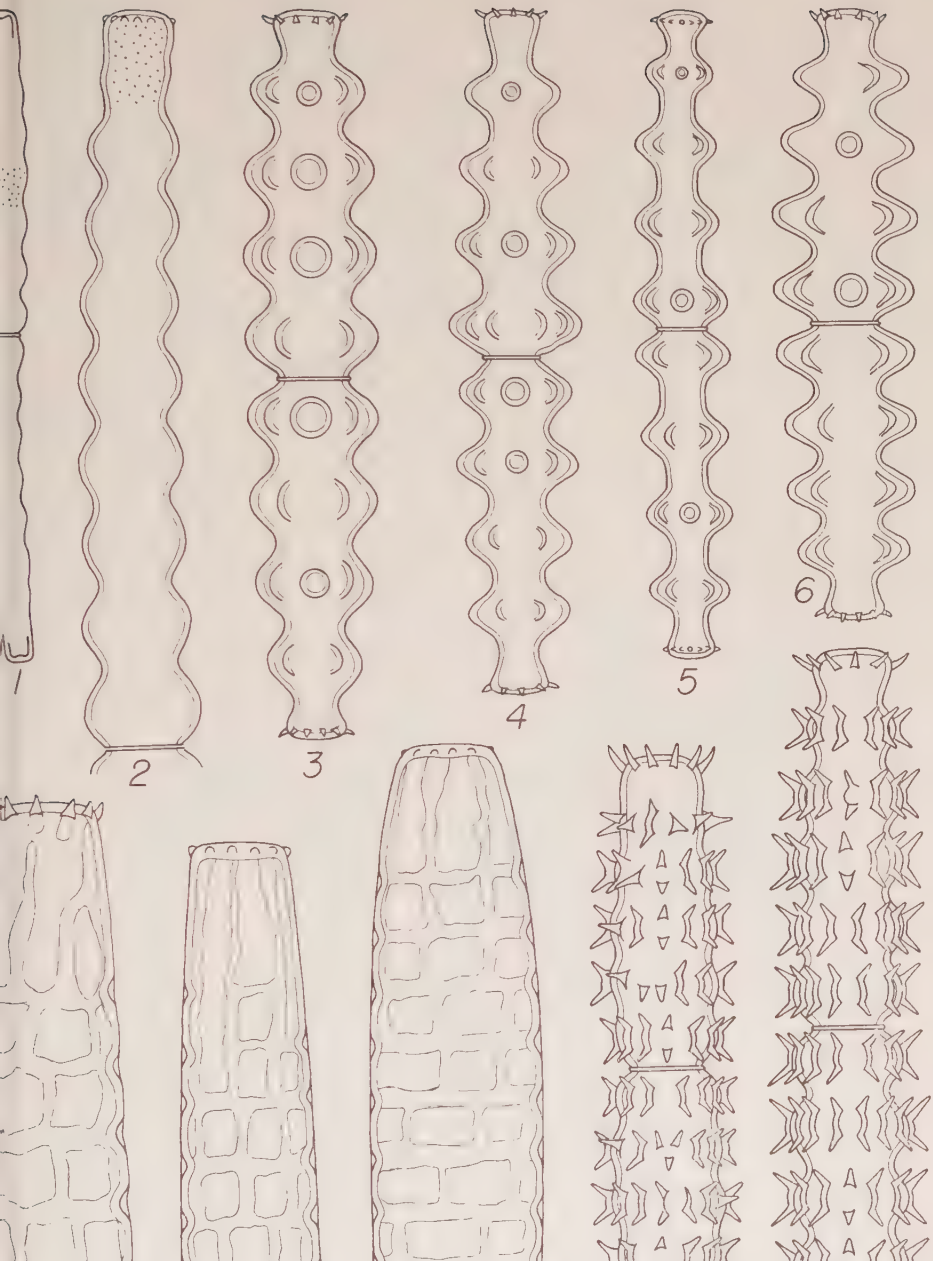


Plate 5

Plate 6.

1, 2. *Pleurotaenium ovatum* Nordst. 1 x260, 2 x315.

3, 4. *P. ovatum* Nordst. var. *inermius* Möbius 3 x420, 4 x310.

5. *Tetmemorus laevis* (Kütz.) Ralfs x610.

6. *T. brebissonii* (Menegh.) Ralfs var. *tenuissimus* Möbius x800.

7, 8. *Triploceras gracile* Bail. fa. *curvatum* fa. nov. 7 x250, 8 x450.

9. *Tr. gracile* Bail. var. *undulatum* Scott & Presc. x440.

10. *Ichthyocercus longispinus* (Borge) Krieg. x825.

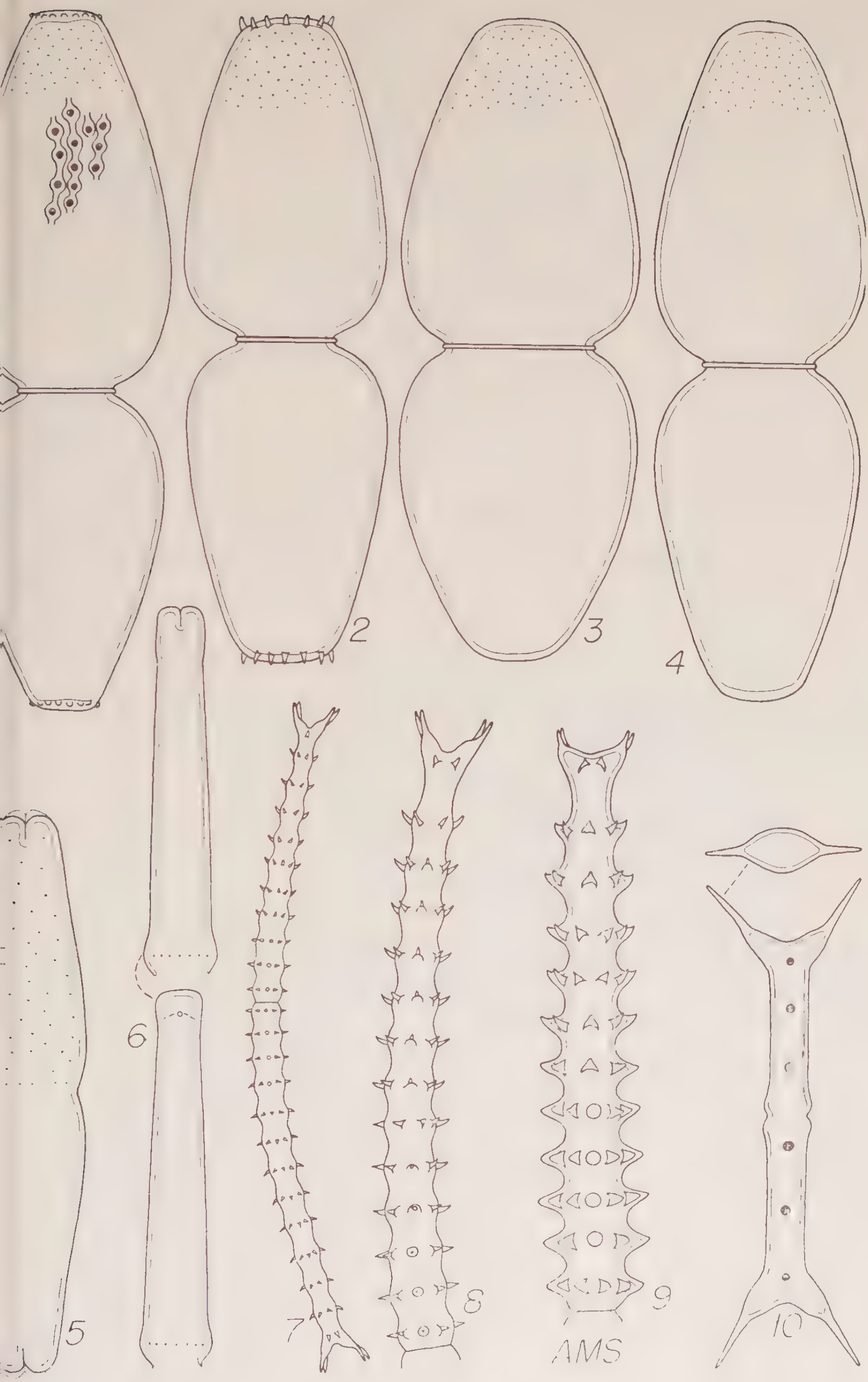


Plate 6

Plate 7.

1. *Ichthyocercus longispinus* (Borge) Krieg., with zygospore. x480.

2. *I. longispinus* (Borge) Krieg. A stouter form with shorter spines. x480.

3. *Ichthyodontum sachlanii* Scott & Presc. x500.

4. *I. sachlanii* Scott & Presc. var. *parorthium* Scott & Presc. x480.

5. Dichotypical cell combining *I. sachlanii* and var. *parorthium*. x500.

6. *Euastrum sinuosum* Lenorm. var. *ceylanicum* West & West x650.

7. *E. pulcherrimum* West & West var. *menggalense* var. nov. x480.

8, 9. *E. sinuosum* Lenorm. var. *capitatum* var. nov. x480.

10. *E. praemorsum* (Nordst.) Schm. x625.

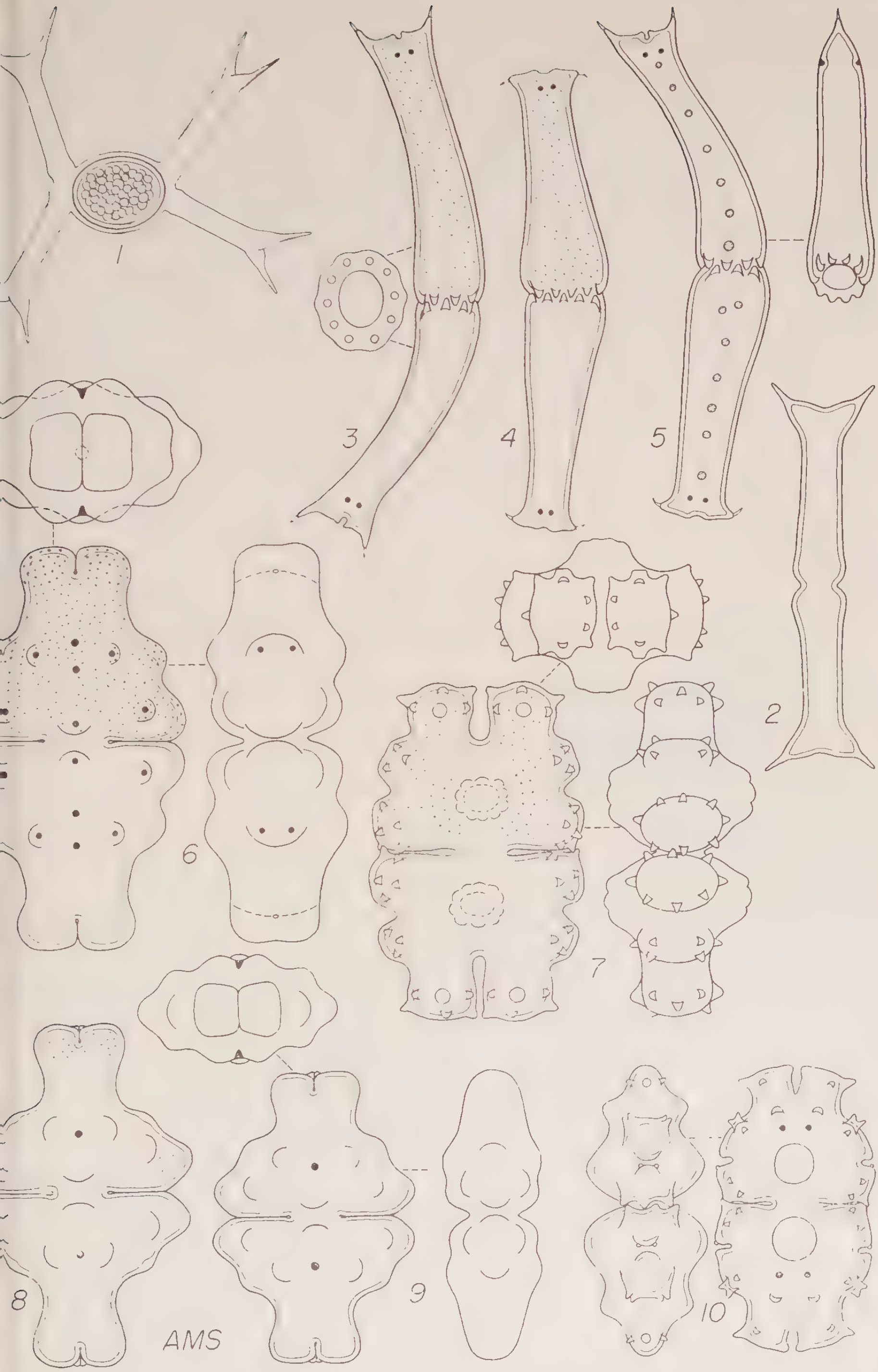


Plate 7

Plate 8.

1. *Euastrum longicolle* Nordst. var. *magnaporum* var. nov. x610.

2, 3. *E. longicolle* Nordst. var. *rotundilobum* var. nov. 2 x610, 3 x800.

4, 5. *E. longicolle* Nordst. var. *capitatum* West & West fa. *minus* Scott & Presc. 4 x810, 5 x780.

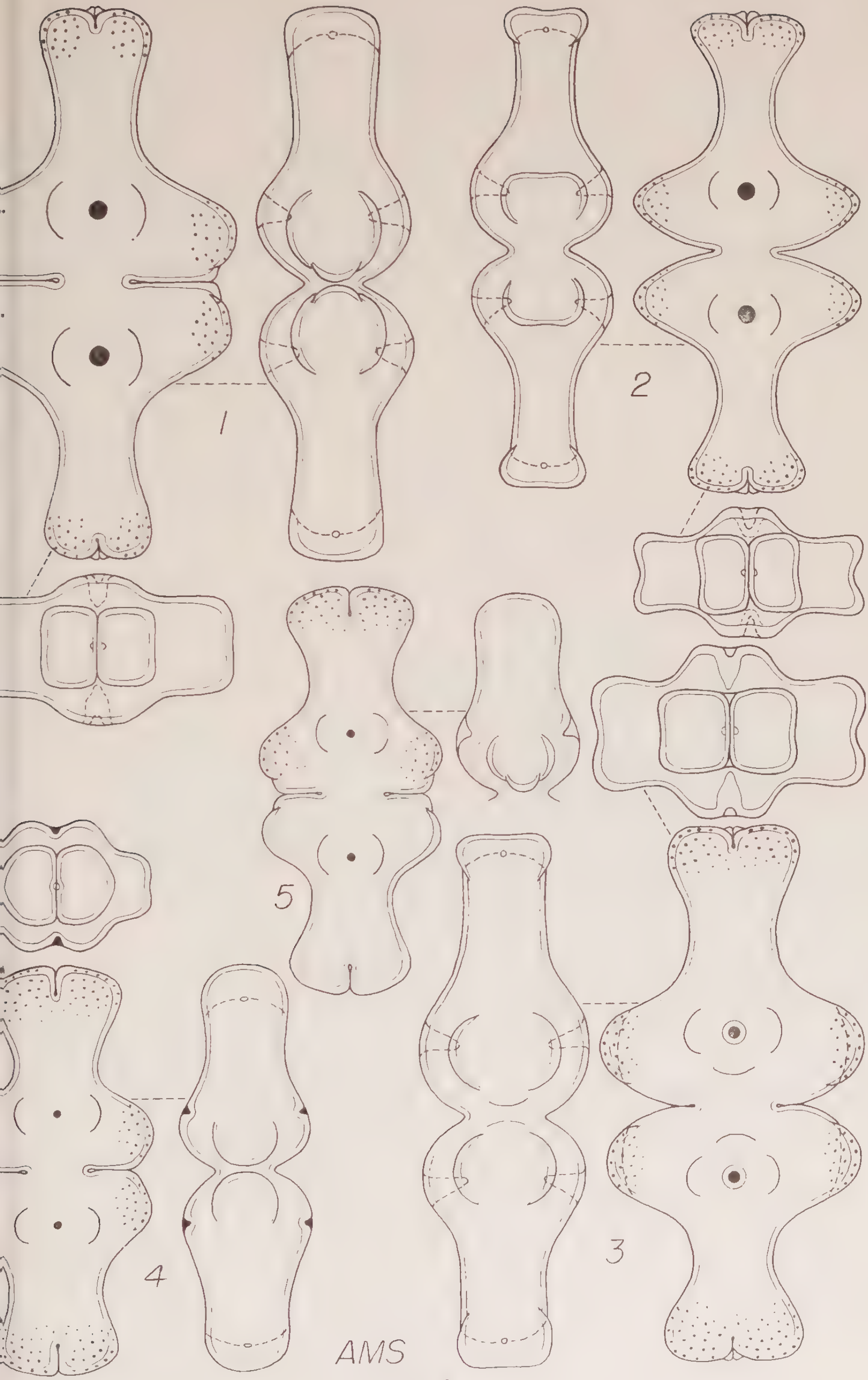


Plate 8

Plate 9.

1. *Euastrum ansatum* Ehrbg. x640.

2. *E. ansatum* Ehrbg. var. *simplex* Ducell. x650.

3. *E. ansatum* Ehrbg. var. *triporum* Krieg. x685.

4. *E. didelta* Ralfs var. *cuneatiforme* Ducell. x640.

5, 6. *E. didelta* Ralfs var. *bengalicum* Lagerh. x485.

7. *E. sinuosum* Lenorm. var. *parallelum* Krieg. Fa. x650.

8. *E. sinuosum* Lenorm. var. *reductum* West & West x640.

9, 10. *E. gnathophorum* West & West var. *bulbosum* var. nov. x640.

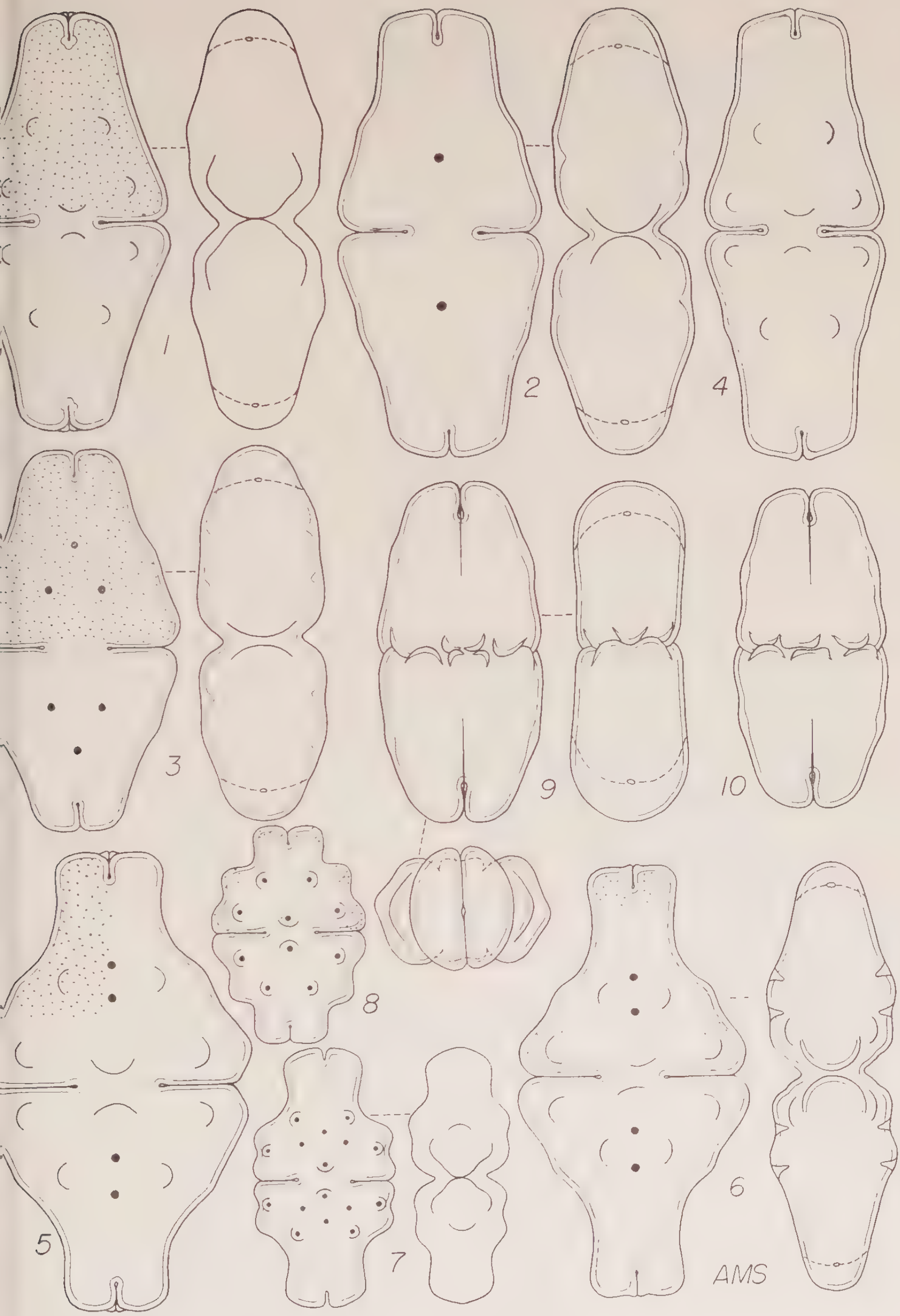


Plate 9

Plate 10.

1, 2. *Euastridium staurastroides* Carter x490.

3. *Euastrum spinulosum* Delp. x710.

4. *E. spinulosum* Delp. Fa. x640.

5. *E. spinulosum* Delp. var. *bellum* var. nov. x640.

6. *E. spinulosum* Delp. var. *vaasii* var. nov. x625.

7. *E. divergens* Josh. var. *ornatum* Schm. x640.

8. *E. subhypochondrum* Fritsch & Rich Fa. x640.

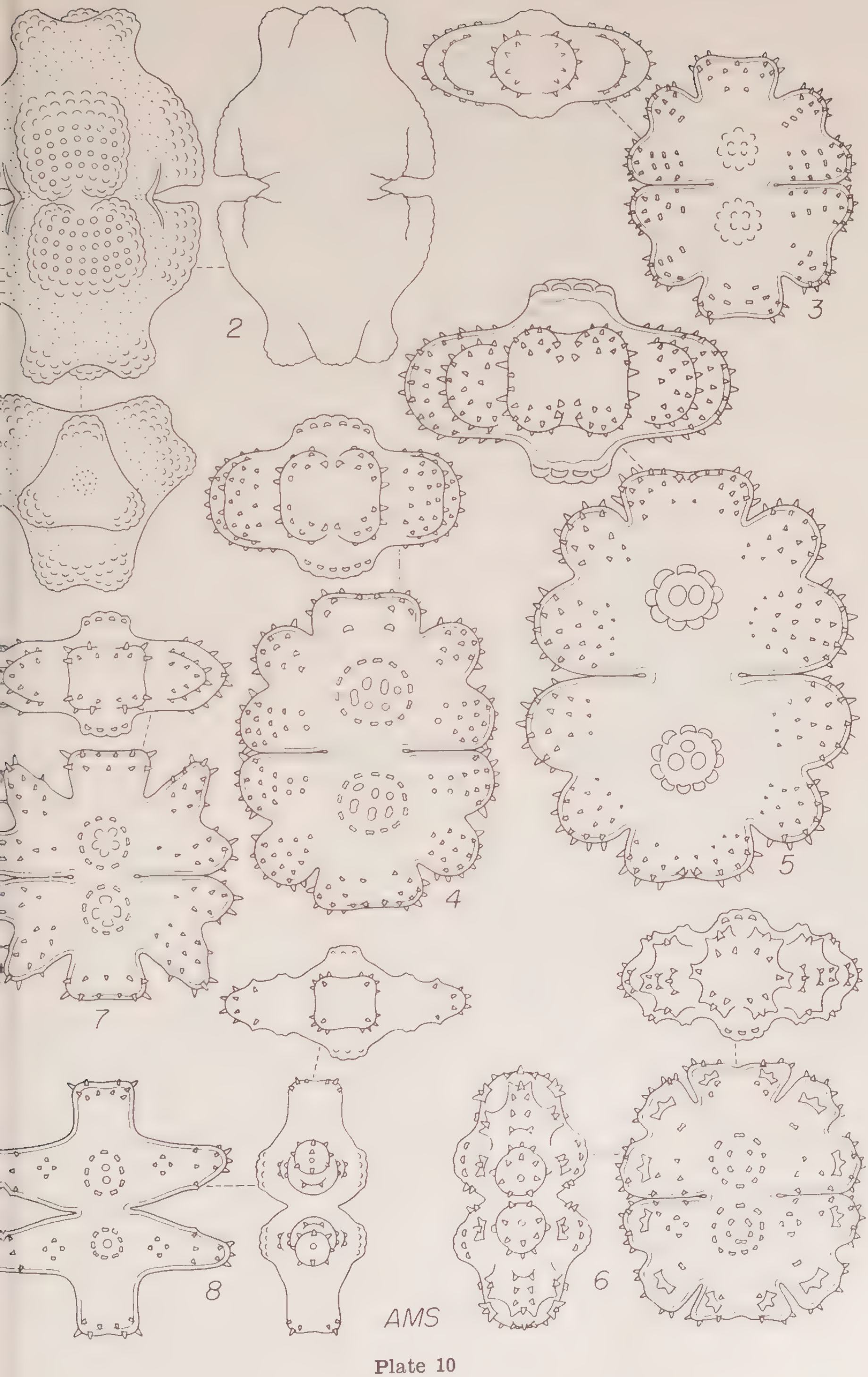


Plate 10

Plate 11.

1, 2. *Euastrum substellatum* Nordst. Formae. x780.

3-5. *E. ceylanicum* (West & West) Krieg. x810.

6, 7. *E. serratum* Josh. x900.

8, 9. *E. rostratum* Ralfs var. *bioculatum* var. nov. 8 x780, 9 x800.

10. *E. flammeum* Josh. x830.

11. *E flammeum* Josh. var. *kalimantanum* var. nov. x800.

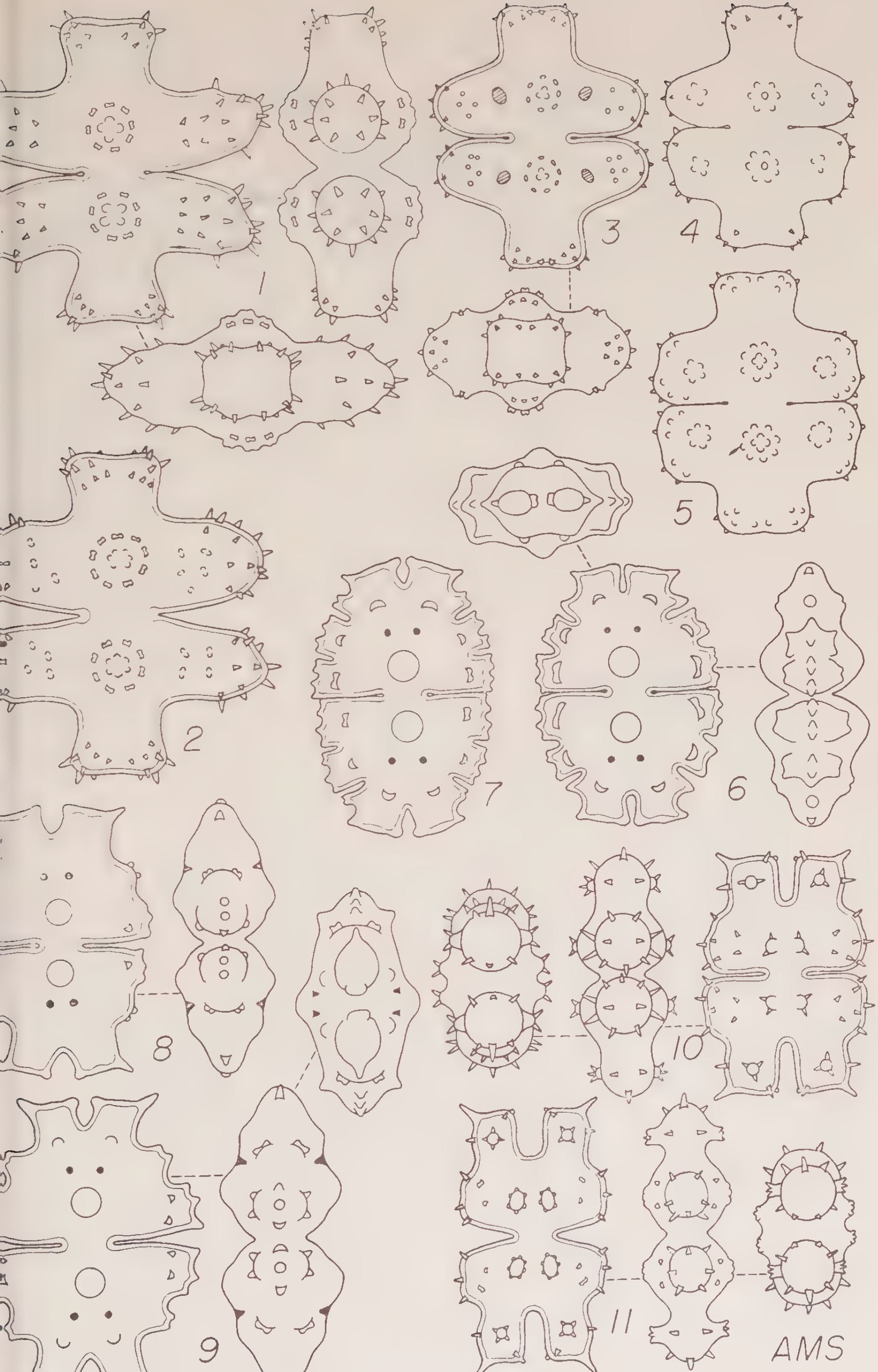


Plate 11

Plate 12.

1. *Euastrum moebii* (Borge) Scott & Presc. comb. nov. var. *burmense* West & West x480.

2, 3. *E. moebii* (Borge) Scott & Presc. var. *tetrachastriforme* West & West fa. *latum* fa. nov. x350.

4, 5. *E. turgidum* Wall. x470.

6. *Micrasterias pinnatifida* (Kütz.) Ralfs x640.

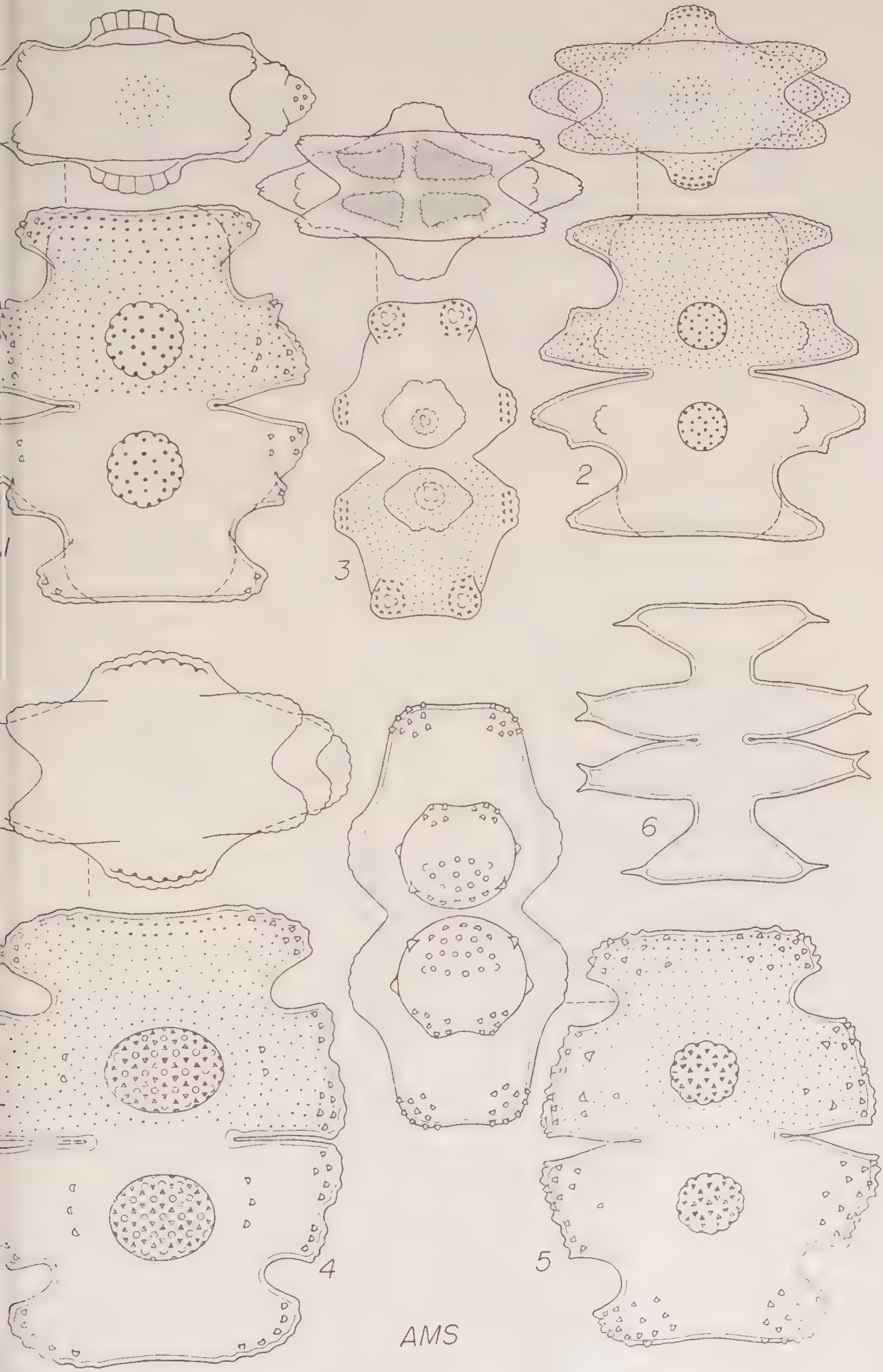


Plate 12

Plate 13.

1, 2. *Euastrum coralloides* Josh. var. *trigibberum* Lagerh. x825.

3. *E. coralloides* Josh. var. *subintegrum* West & West Fa. x775.

4, 5. *E. acanthophorum* Turn., with zygospore. x800.

6, 7. *E. acanthophorum* Turn. fa. *minus* fa. nov. 6 x930, 7 x800.

8. *E. antistrophum* sp. nov. x880.

9. *E. bipartitum* Krieg. x840.

10. *E. denticulatum* (Kirchn.) Gay var. *quadrifarium* Krieg. x900.

11. *E. denticulatum* (Kirchn.) Gay var. *quadrifarium* Krieg. Fa. x850.

12. *E. denticulatum* (Kirchn.) Gay var. *quadrifarium* Krieg. fa. *incisum* Scott & Presc. x800.

13. *E. distortum* sp. nov. x800.

14. *E. mirum* Behre x820.

15. *E. mirum* Behre, a much larger form. x760.

16. *E. dubium* Näg. var. *ornatum* Wolosz. Fa. x800.

17. *E. elegans* (Bréb.) Kütz. Fa. x850.

18. *E. incavatum* Josh. & Nordst. var. *platycephalum* var. nov. x800.


Plate 13

Plate 14.

1. *Euastrum elobatum* (Lund.) Roy & Biss. var. *oculatum* var. nov. x820.

2. *E. exile* Josh. x790.

3. *E. gayanum* De Toni Fa. x1200.

4. *E. inornatum* sp. nov. x800.

5. *E. subrostratum* West & West var. *reductum* var. nov. x800.

6. *E. rectangulare* Fritsch & Rich var. *sumatranum* var. nov. x1100.

7. *E. subprojectum* sp. nov. x780.

8. *E. luetkemuelleri* Ducell. Fa. x800.

9. *E. luetkemuelleri* Ducell. var. *carniolicum* (Lütkem.) Krieg. Fa. x820.

10. *E. luetkemuelleri* Ducell. var. *menggalense* var. nov. x740.

11. *E. gessneri* Krieg. & Bourr. var. *laticeps* var. nov. x800.

12. *E. quadrioculatum* West & West var. *curtum* var. nov. x800.

13. *E. sublobatum* Bréb. var. *incrassatum* var. nov. x1130.

14. *E. sublobatum* Bréb. var. *sumatranum* var. nov. x1060.

15. *E. subvalidum* Behre Fa. x800.

16. *E. vinnulum* sp. nov. x875.

17, 18. *Micrasterias pinnatifida* (Kütz.) Ralfs Formae. x600.

19. *M. pinnatifida* (Kütz.) Ralfs var. *pseudoscitans* Grönbl. x780.

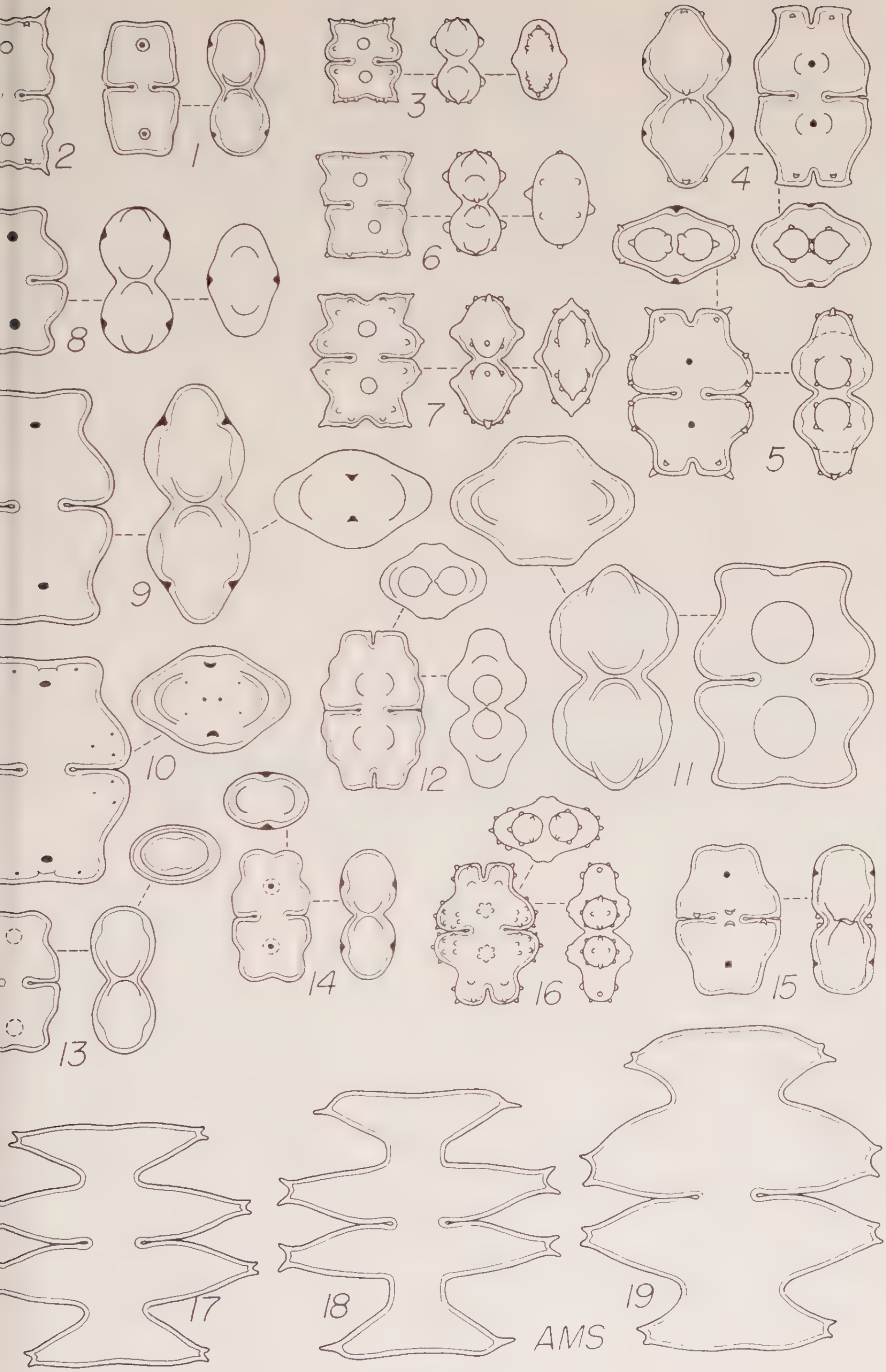


Plate 14

Plate 15.

1. *Euastrum prowsei* sp. nov. x630.

2, 3. *Micrasterias ceratofera* Josh. 2 x240, 3 x330.

4. *M. alata* Wall. x340.

5, 6. *M. foliacea* Bail. var. *quadrinflata* var. nov. Fig. 6 is a basal view. x650.

7, 8. *M. foliacea* Bail. var. *quadrinflata* var. nov. A form with four additional spines on each semicell. Fig. 8 is an optical section through the inflationsas seen from above, x650.

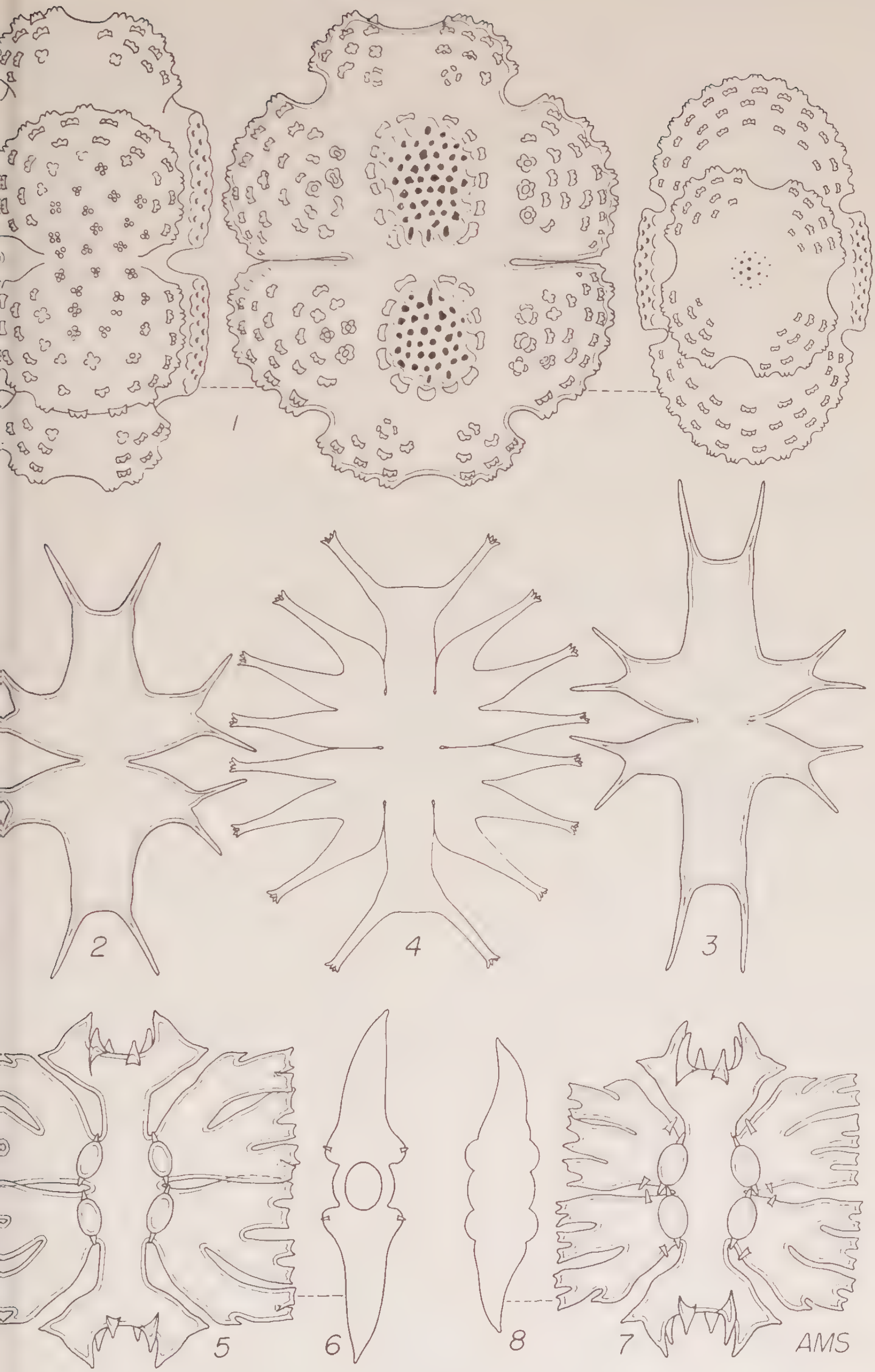


Plate 15

Plate 16.

1, 2. *Micrasterias mahabuleshwarensis* Hobs. var. *surculifera* Lagerh. 1 x480, 2 x350.

3-5. *M. mahabuleshwarensis* Hobs. var. *chauliodon* var. nov. 3 x650, 4 x470, 5 x650.

6. *M. mahabuleshwarensis* Hobs. var. *bengalica* (Lagerh.) Krieg. x475.

7. *M. tropica* Nordst. var. *polonica* Eichl. & Gutw. fa. *evoluta* fa. nov. x630.

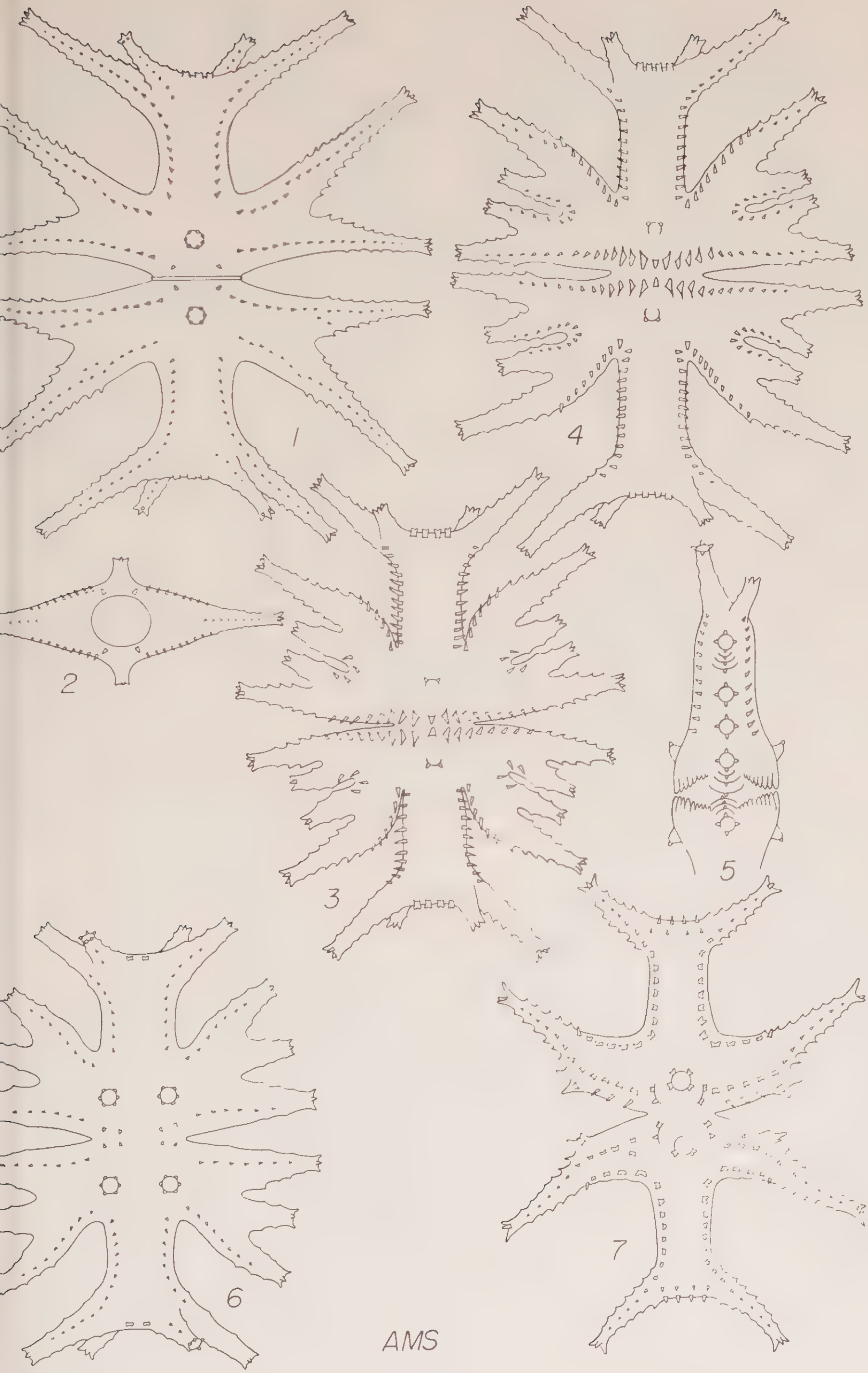


Plate 16

Plate 17.

1. *Micrasterias lux* Josh. x400.

2. *M. lux* Josh. Teratological semicell. x360.

3. *M. lux* Josh. ad var. *longibracchiata* Behre *accedens*. x345.

4. *M. lux* Josh. var. *sachlanii* var. nov. x310.

5. *M. lux* Josh. var. *brevibracchiata* Behre fa. *spinosa* fa. nov. x350.

6. *M. thomasiana* Arch. var. *notata* (Nordst.) Grönbl. x256.

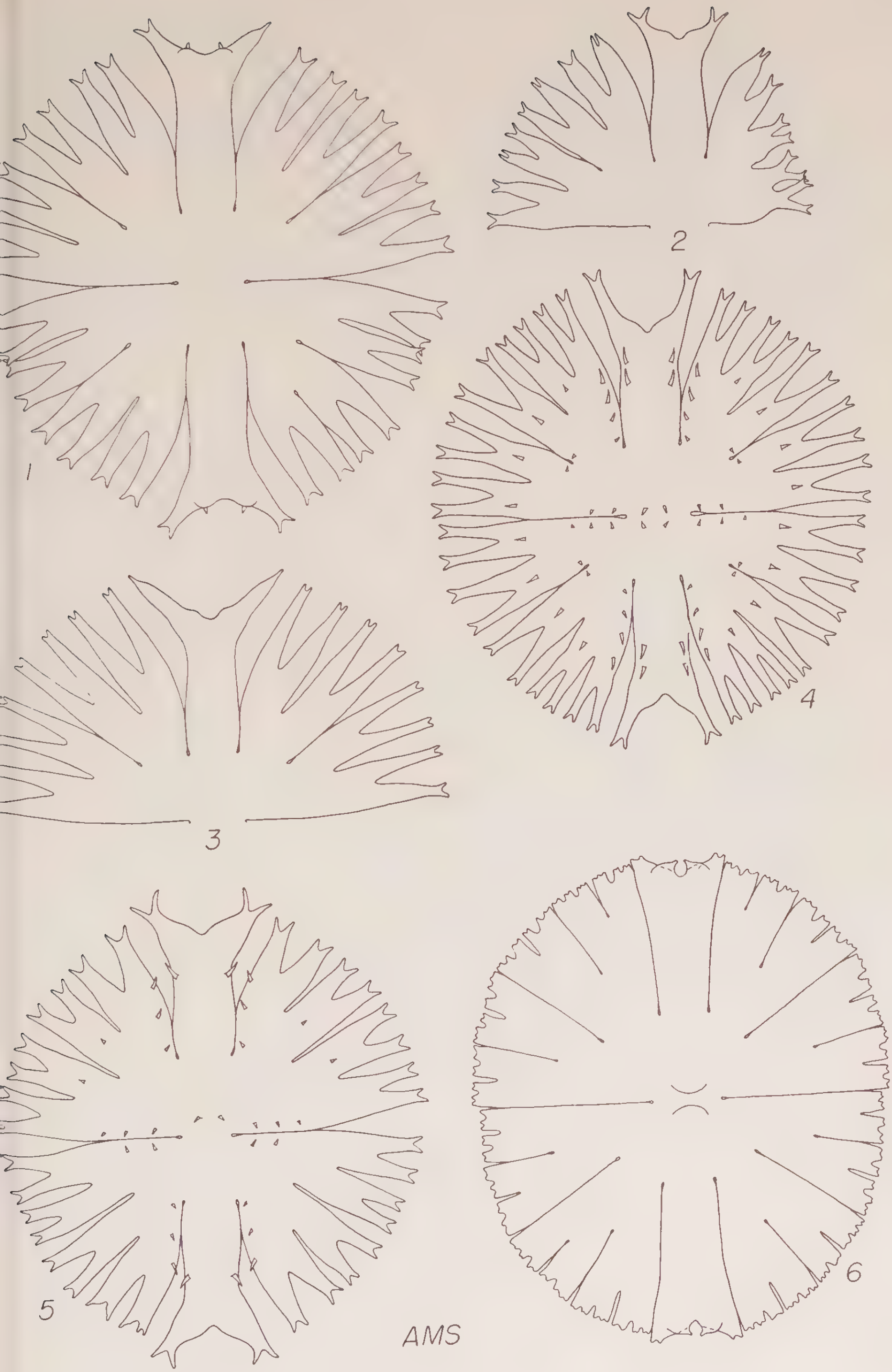


Plate 17

Plate 18.

1. *Micrasterias apiculata* (Ehrbg.) Menegh. var. *lacerata* Turn. x305.

2. *M.apiculata* (Ehrbg.) Menegh. var. *lacerata* Turn. fa. *elaborata* fa. nov. x360.

3, 4. *M. quadridentata* (Nordst.) Grönbl. fa. *indonesiensis* fa. nov. x255.

5. *M. subincisa* Krieg. x640.

6. *M. subincisa* Krieg. var. *mandibula* Krieg. x640.

7, 8. *M. arcuata* Bail. var. *robusta* Borge fa. *recurvata* Presc. & Scott x640.

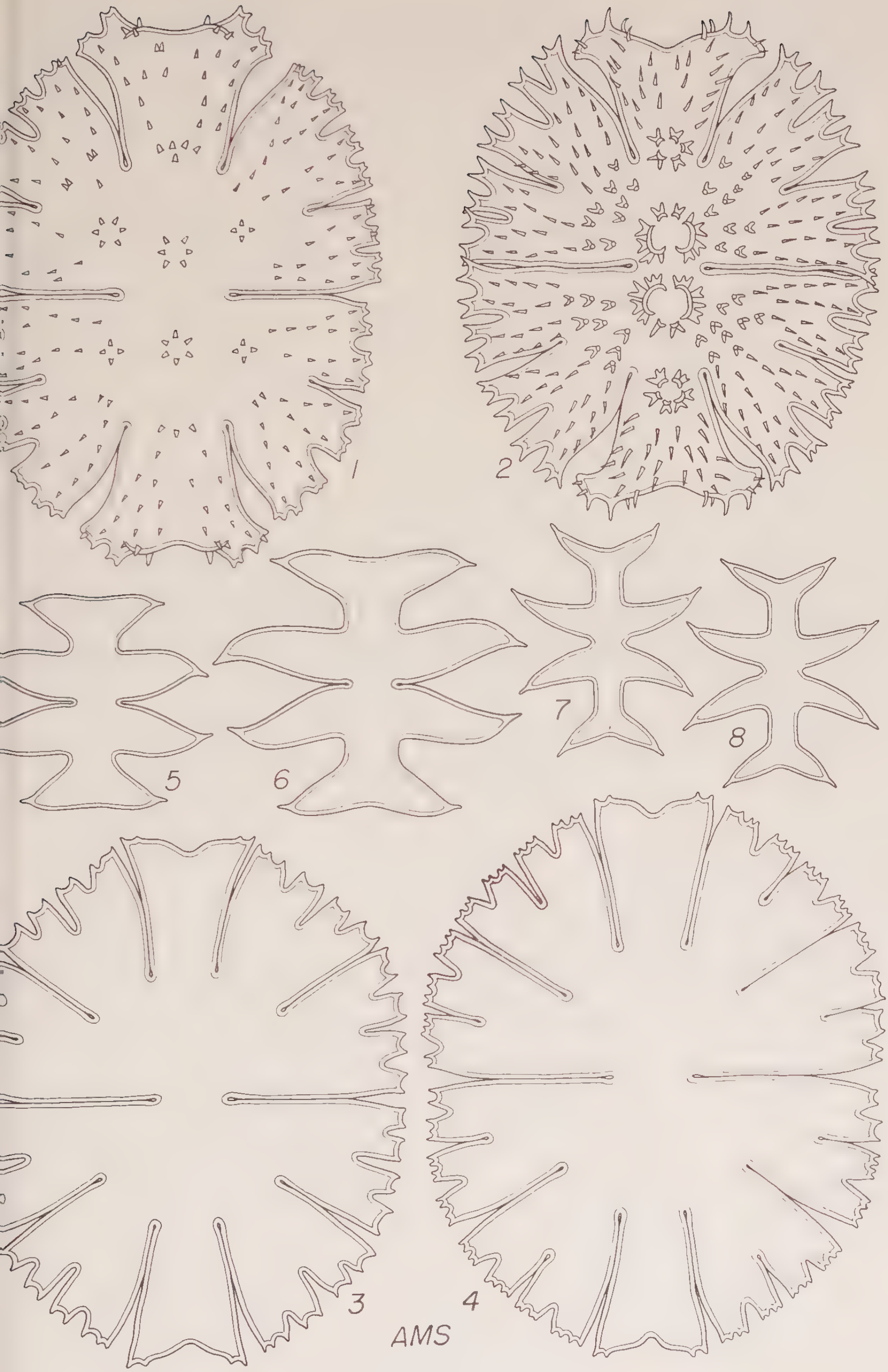


Plate 18

Plate 19.

1-3. *Micrasterias anomala* Turn. 1 x330, 2 x305, 3 x245.

4. *M. anomala* Turn. Side view showing the doubling of two of the lateral lobules, similar to those so indicated in Fig. 1. x245.

5-7. *M. anomala* Turn. var. *reducta* var. nov. 5, 6 x340, 7 x245.

8. *M. subincisa* Krieg. var. *mandibula* Krieg. x640.

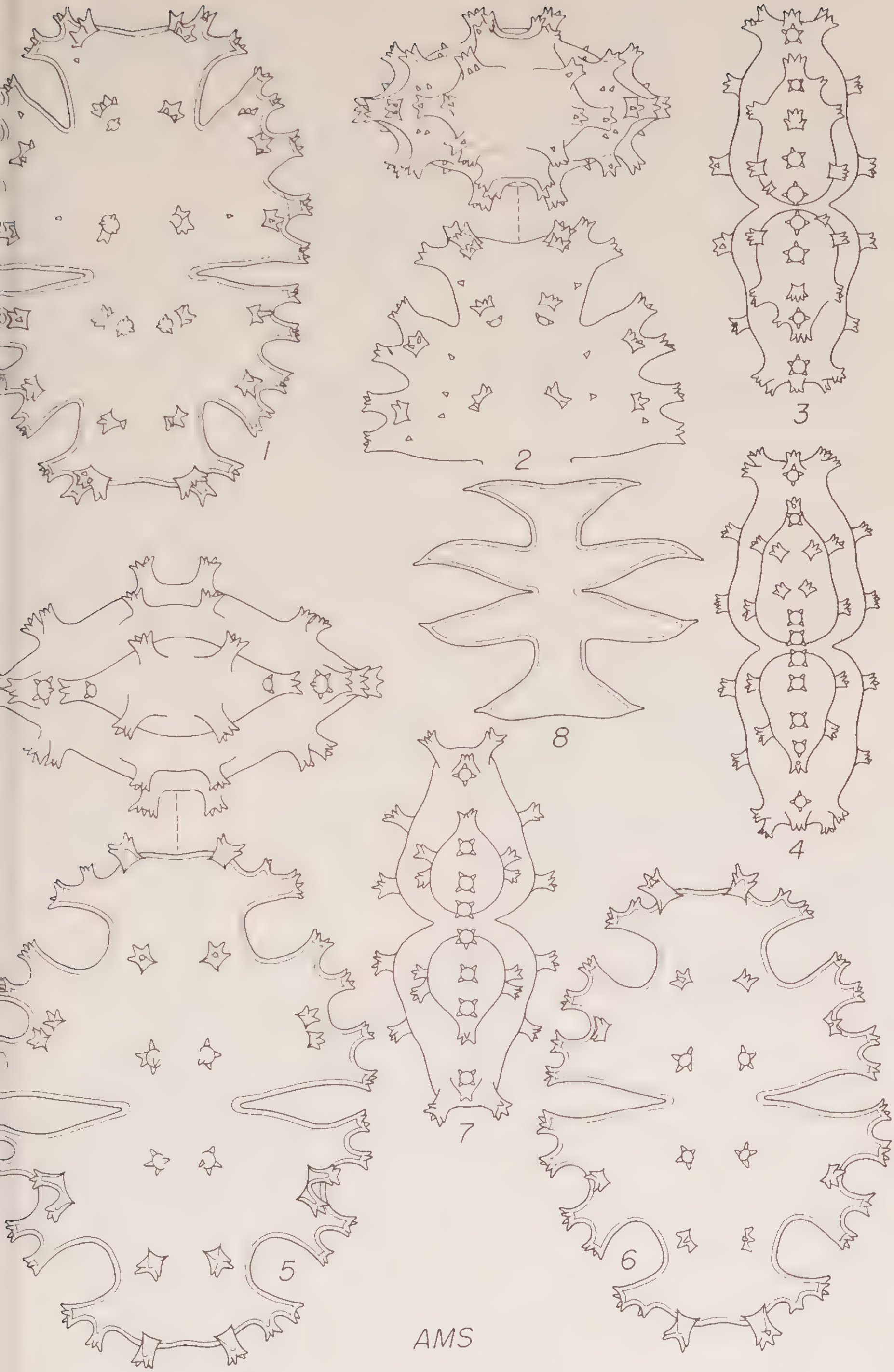


Plate 19

Plate 20.

1, 2. *Micrasterias anomala* Turn. var. *kalimantana* var. nov. 1 x335, 2 x255.

3. *M. anomala* Turn. var. *sumatrana* var. nov. x250.

4. *M. foliacea* Bail. Fa. x500.

5. *M. foliacea* Bail, var. *ornata* Nordst. Sigmoidal form. x450.

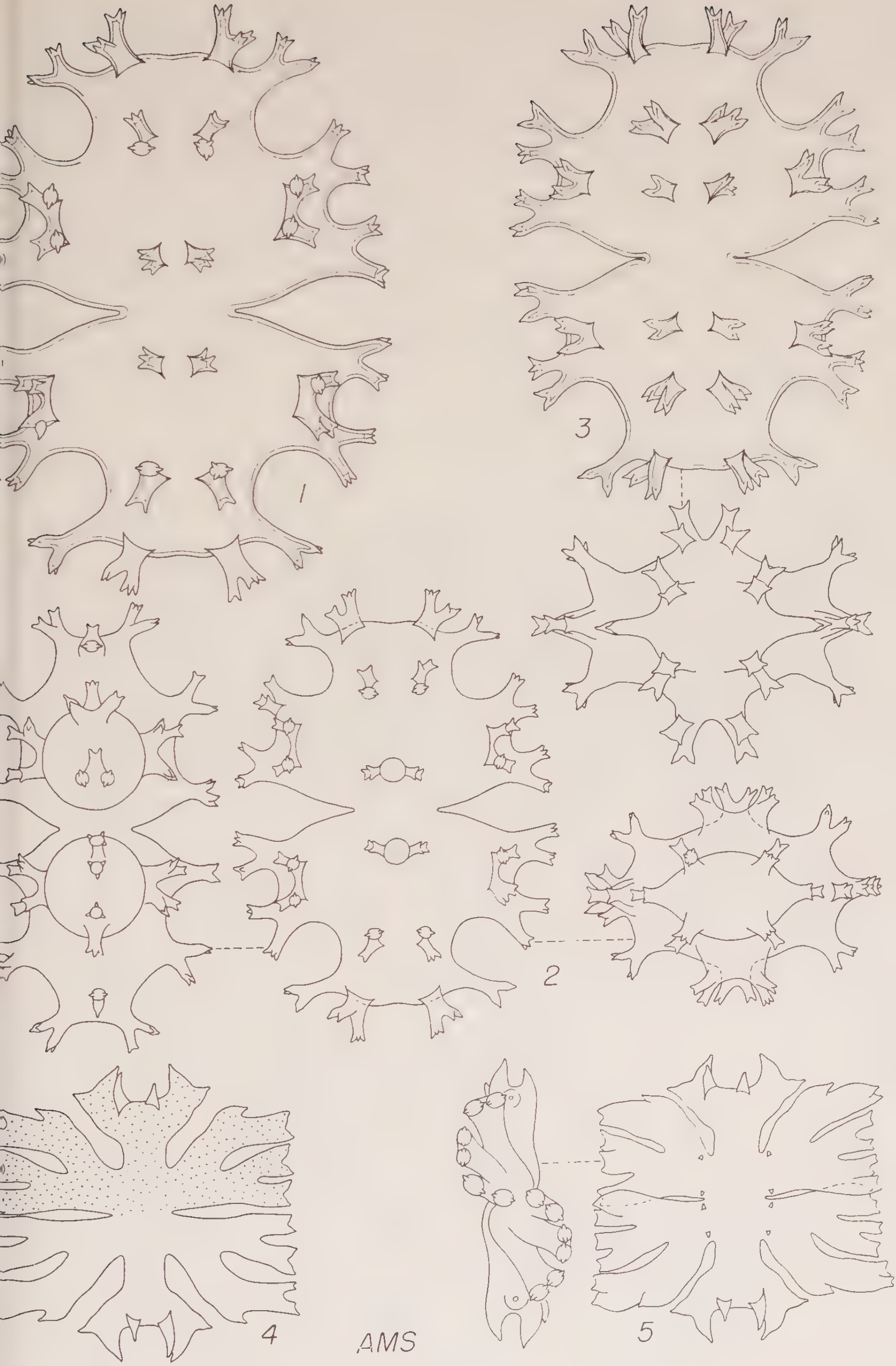


Plate 20

Plate 21.

1. *Micrasterias torreyi* Bail. var. *crameri* (Bern.) Krieg. x178.

2. *M. torreyi* Bail. var. *curvata* Krieg. Fa. x248.

3. *M. torreyi* Bail. var. *doveri* (Biswas) Krieg. x205.

4. *M. torreyi* Bail. var. *sachlanii* var. nov. x210. Enlarged from a photomicrograph by M. SACHLAN.

5-7. *M. zeylanica* Fritsch var. *rectangularis* var. nov. x640.

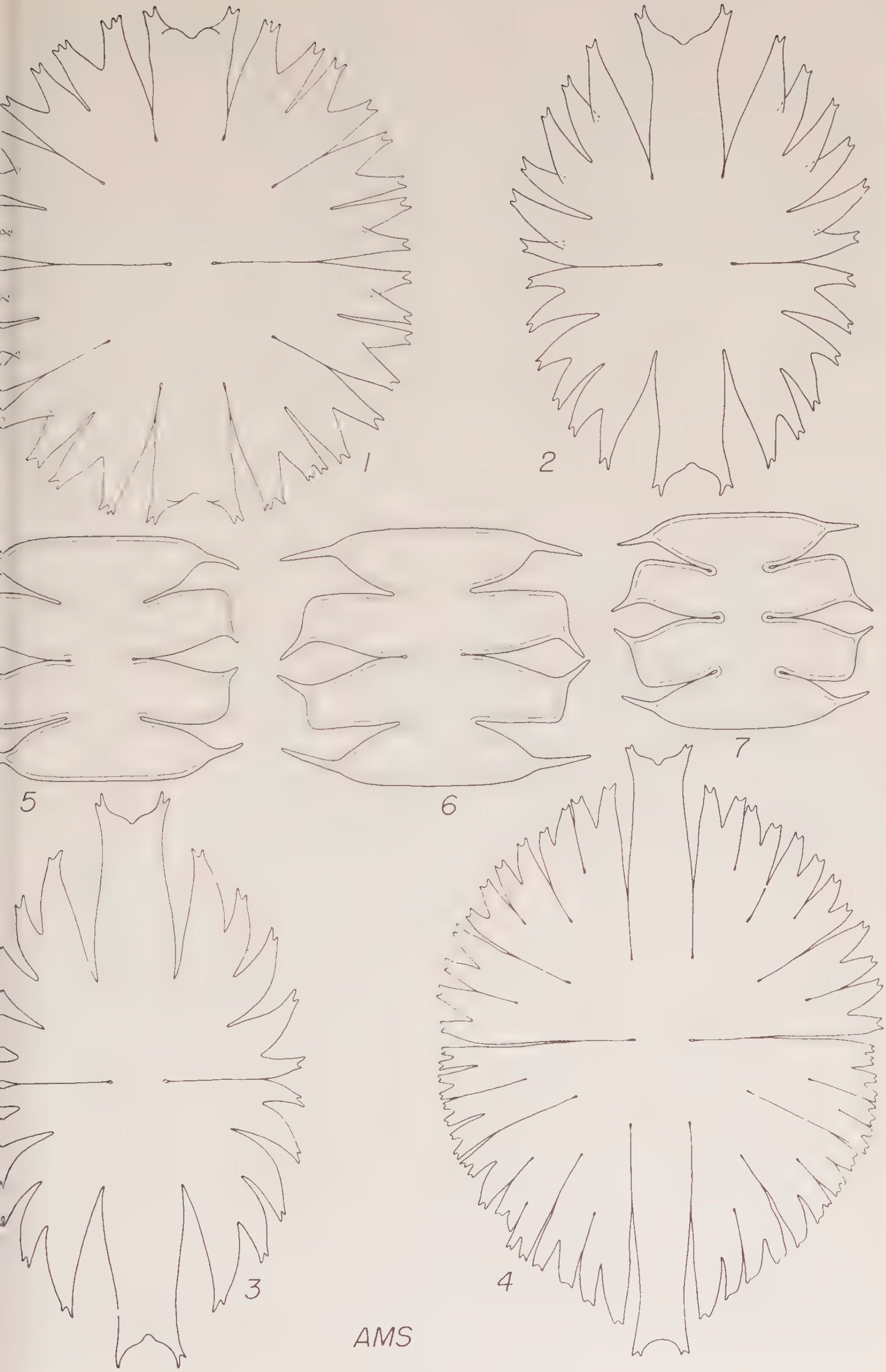


Plate 21

Plate 22.

1. *Micrasterias jenneri* Ralfs x335.

2. *M. jenneri* Ralfs var. *simplex* W. West Fa. x335.

3, 4. *M. suboblonga* Nordst. var. *tecta* Krieg. Formae. x490.

5, 6. *M. thomasiana* Arch. var. *evoluta* Krieg. 5 x310, 6 x240.

7. *M. ceratofera* Josh. Side view. x265.

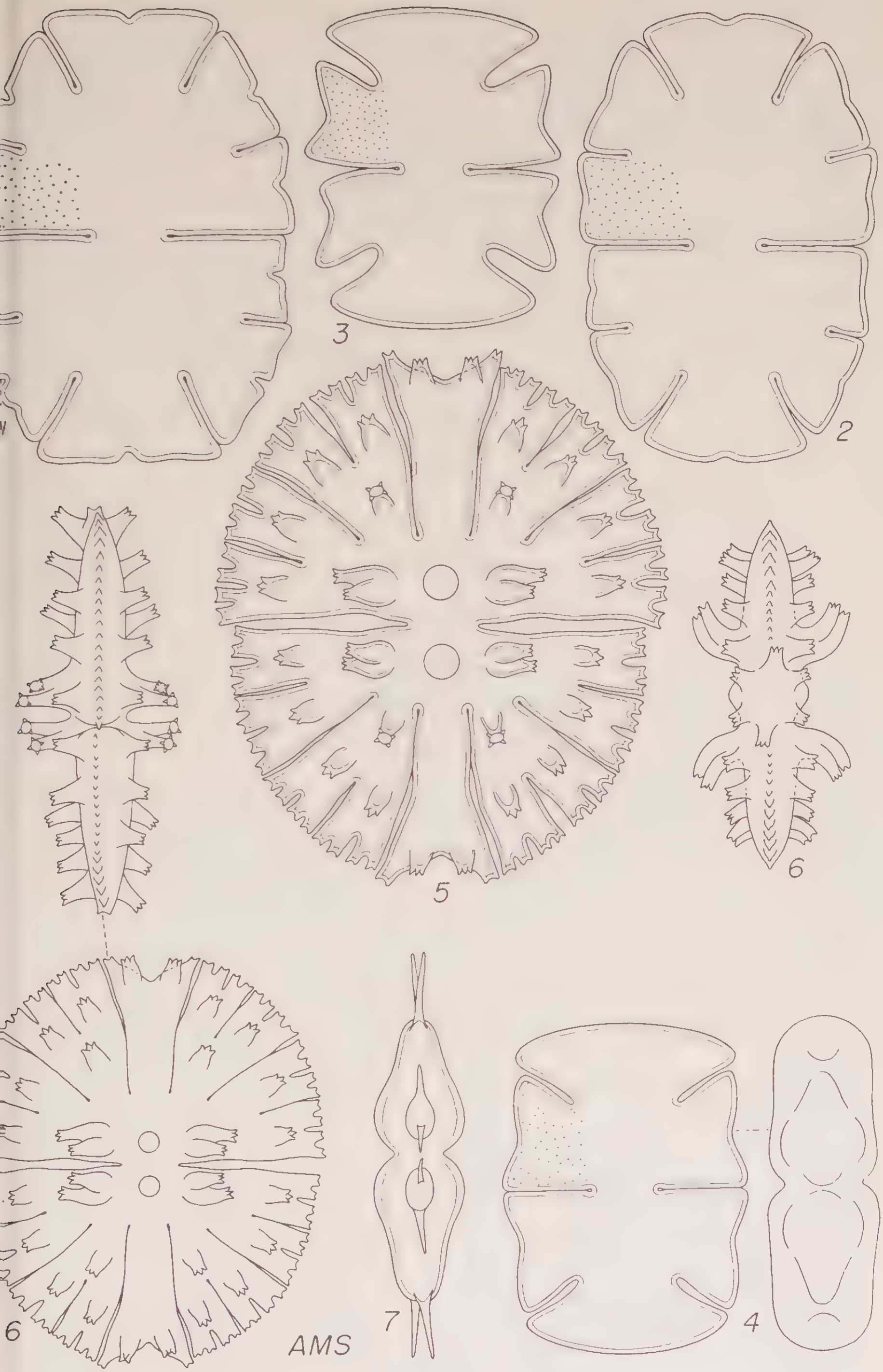


Plate 22

Plate 23.

1. *Micrasterias radians* Turn. x500.

2, 3. *M. radians* Turn. var. *bogoriensis* (Bern.) G. S. West 2 x460, 3 x400.

4. *Cosmarium askenasyi* Schm. x340.

5. *C. askenasyi* Schm. fa. *latum* Scott & Presc. x350.

6. *C. subturgidum* (Turn.) Schm. fa. *minus* Schm. x500.

7. *C. cucurbitinum* (Biss.) Lütkem. x640.

8. *C. cucurbitinum* (Biss.) Lütkem. var. *longum* Scott & Grönbl. x500.

9. *C. cucurbitinum* (Biss.) Lütkem. var. *truncatum* Krieg. x640.

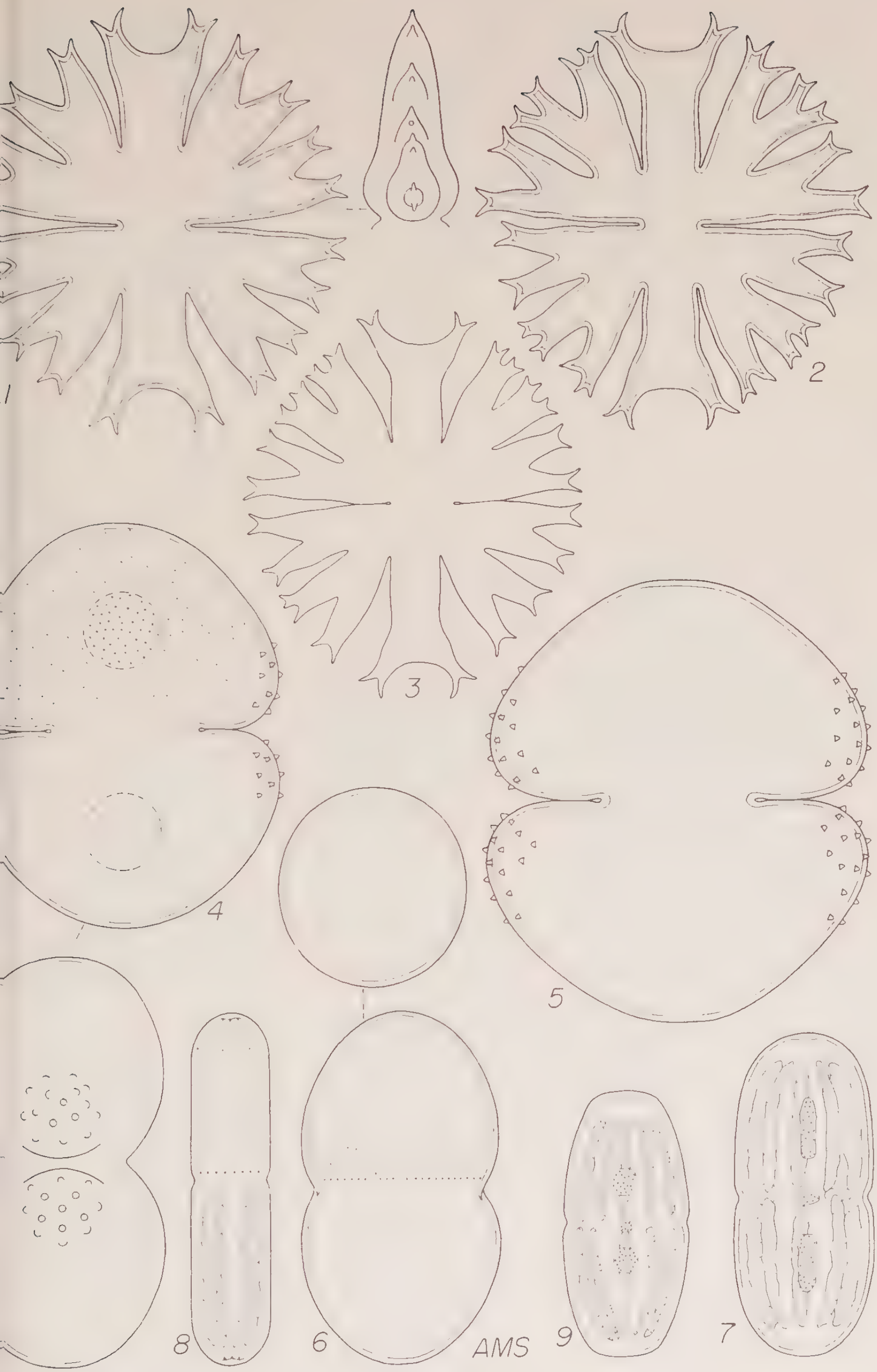


Plate 23

Plate 24.

1. *Cosmarium denticulatem* Borge var. *ellipsoideum* var. nov. x475.

2. *C. maculatum* Turn. x380.

3, 4. *C. magnificum* Nordst. var. *granulorum* var. nov. x660.

5. *C. magnificum* Nordst. var. *subcirculare* Skuja Fa. x650.

6, 7. *C. lagerheimianum* (Turn.) Scott & Presc. comb. nov. 6 x520, 7 x580.

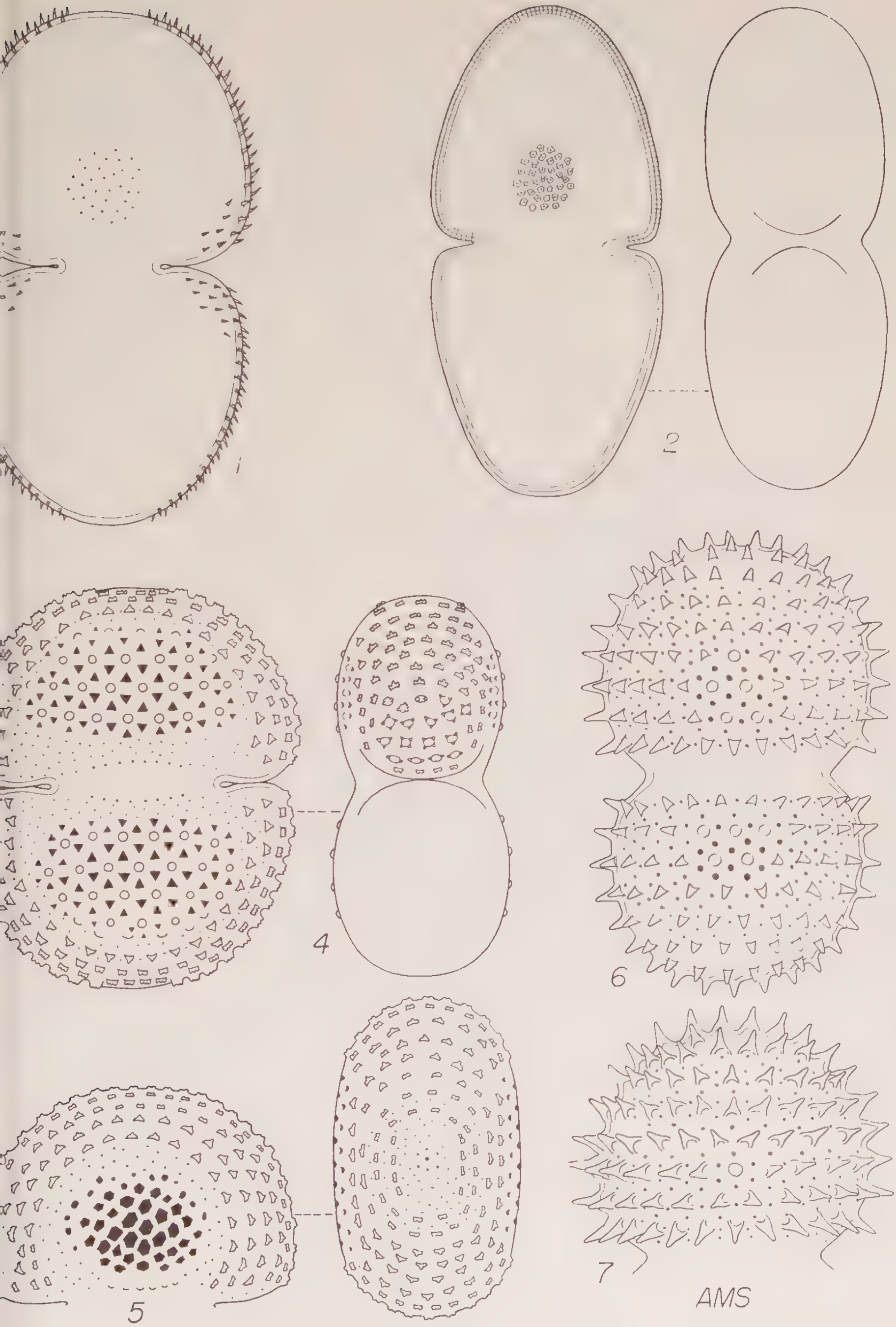


Plate 24

Plate 25.

1. *Cosmarium decoratum* West & West x625.

2, 3. *C. striolatum* Näg. 2 x470, 3 x490.

4. *C. pseudoconnatum* Nordst. x625.

5. *C. pachydernum* Lund. Fa. x640.

6. *C. lundellii* Delp. x640.

7. *C. lundellii* Delp. var. *circulare* (Reinsch) Krieg. x640.

8. *C. lundellii* Delp. var. *ellipticum* W. West x640.

9. *C. lundellii* Delp. var. *corruptum* Turn. x660.

10. *C. lundellii* Delp. fa. *crassangulatum* fa. nov. x640.

11. *C. obsoletum* (Hantzsch) Reinsch var. *sitvense* Gutw. x640.

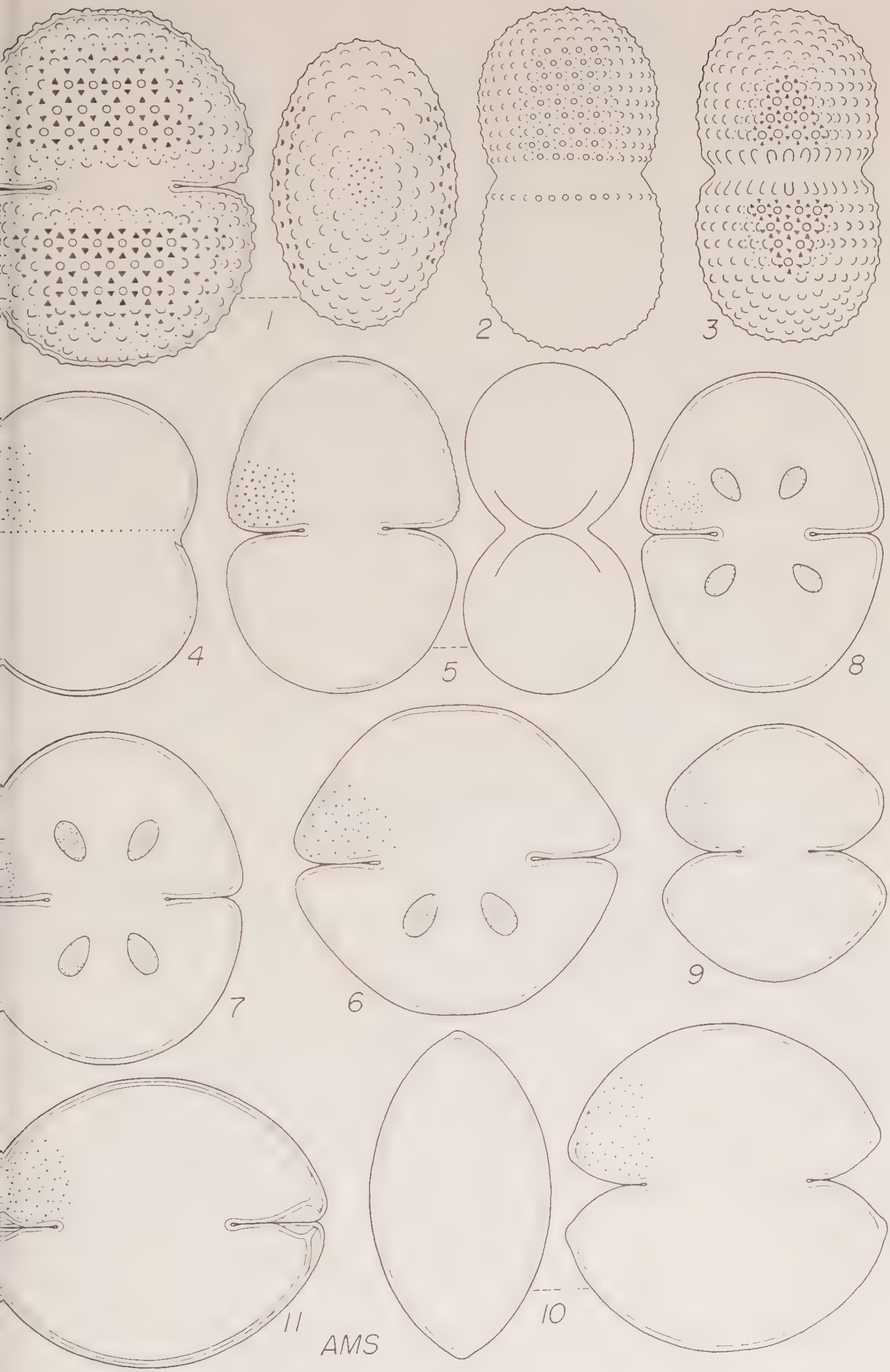


Plate 25

Plate 26.

1. *Cosmarium obsoletum* (Hantzsch) Reinsch x780.

2. *C. obsoletum* (Hantzsch) Reinsch var. *sitvense* Gutw. Abnormal division. x790.

3. *C. medioscrobiculatum* West & West var. *egranulatum* Gutw. x790.

4. *C. auriculatum* Reinsch x770.

5. *C. subauriculatum* West & West var. *truncatum* West & West x780.

6. *C. depressum* (Näg.) Lund. x800.

7. *C. depressum* (Näg.) Lund. var. *apertum* (Turn.) Hirano x760.

8. *C. perfissum* G. S. West Fa. x820.

9. *C. cucurbita* Bréb. fa. *rotundatum* Krieg. x800.

10-11. *C. globosum* Bulnh. var. *wollei* West & West Fa. x800.

12. *C. westii* Bern. x800.

13. *C. inornatum* Josh. x800.

14. *C. trachypolum* West & West x840.

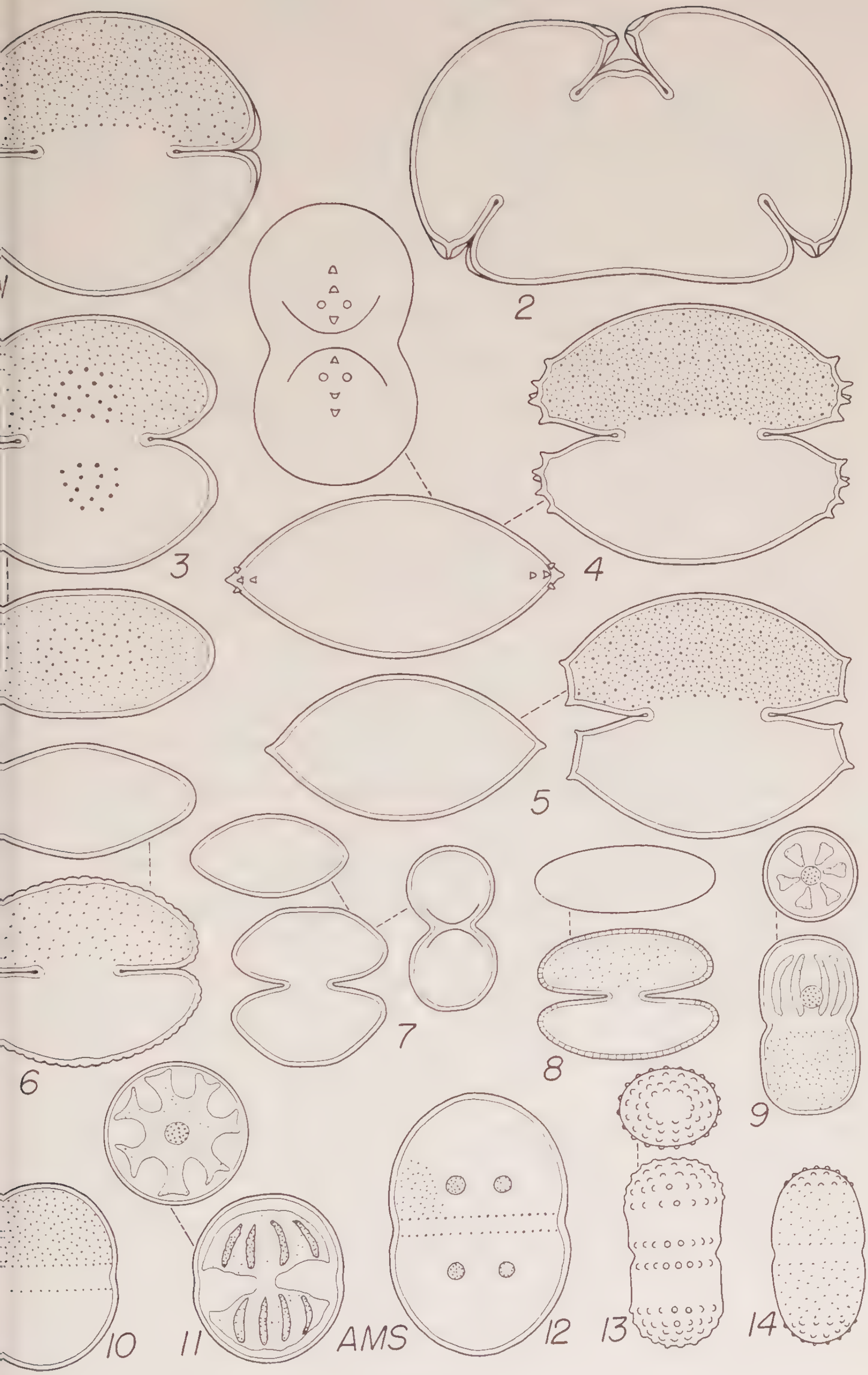


Plate 26

Plate 27.

1. *Cosmarium pyramidatum* Bréb. x790.

2, 3. *C. pseudopyramidatum* Lund. var. *oculatum* Krieg., with zygospore. 2 x790, 3 x600.

4. *C. contractum* Kirchn. x790.

5. *C. contractum* Kirchn. var. *incrassatum* Scott & Presc. x760.

6. *C. contractum* Kirchn. var. *pachydermum* Scott & Presc. x790.

7. *C. indentatum* Grönbl. var. *ellipticum* Scott & Grönbl. x760.

8. *C. tjibenongense* Gutw. fa. *minus* G. S. West x790.

9. *C. aversum* West & West var. *sumatranum* var. nov. x790.

10. *C. moniliforme* (Turp.) Ralfs var. *indentatum* Scott & Grönbl. fa. x770.

11, 12. *C. moniliforme* (Turp.) Ralfs var. *limneticum* West & West 11 x810, 12 x300.

13, 14. *C. nymannianum* Grun. with zygospore. 13 x770, 14 x600.

15. *C. peniomorphum* Scott & Presc. var. *latior* Scott & Presc. x820.

16. *C. tumidum* Lund. x760.

17. *C. granatum* Bréb. var. *rotundatum* Krieg. x875.

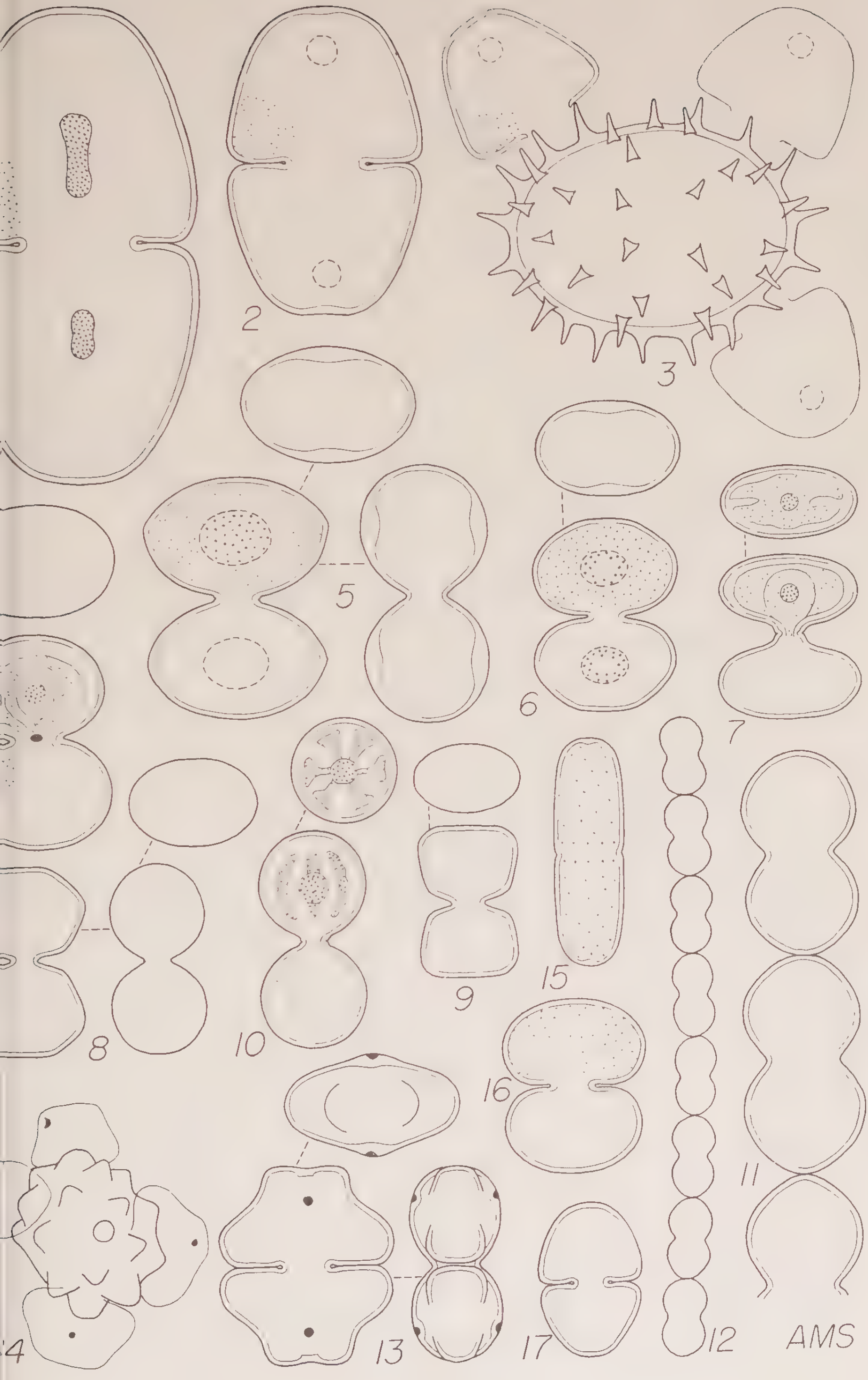


Plate 27

Plate 28.

1. *Cosmarium angulatum* (Perty) Rab. fa. *majus* Grunow x820.

2, 3. *C. binerve* Lund. x810.

4. *C. binerve* Lund. var. *subangulatum* var. nov. x840.

5. *C. zonatum* Lund. x840.

6-7. *C. zonatum* Lund. var. *pyriforme* var. nov. x810.

8. *C. portianum* Arch. A very small form. x850.

9. *C. portianum* Arch. var. *majus* var. nov. x800.

10. *C. portianum* Arch. var. *nephroideum* Wittr. Fa. x800.

11-12. *C. mansangense* West & West x780.

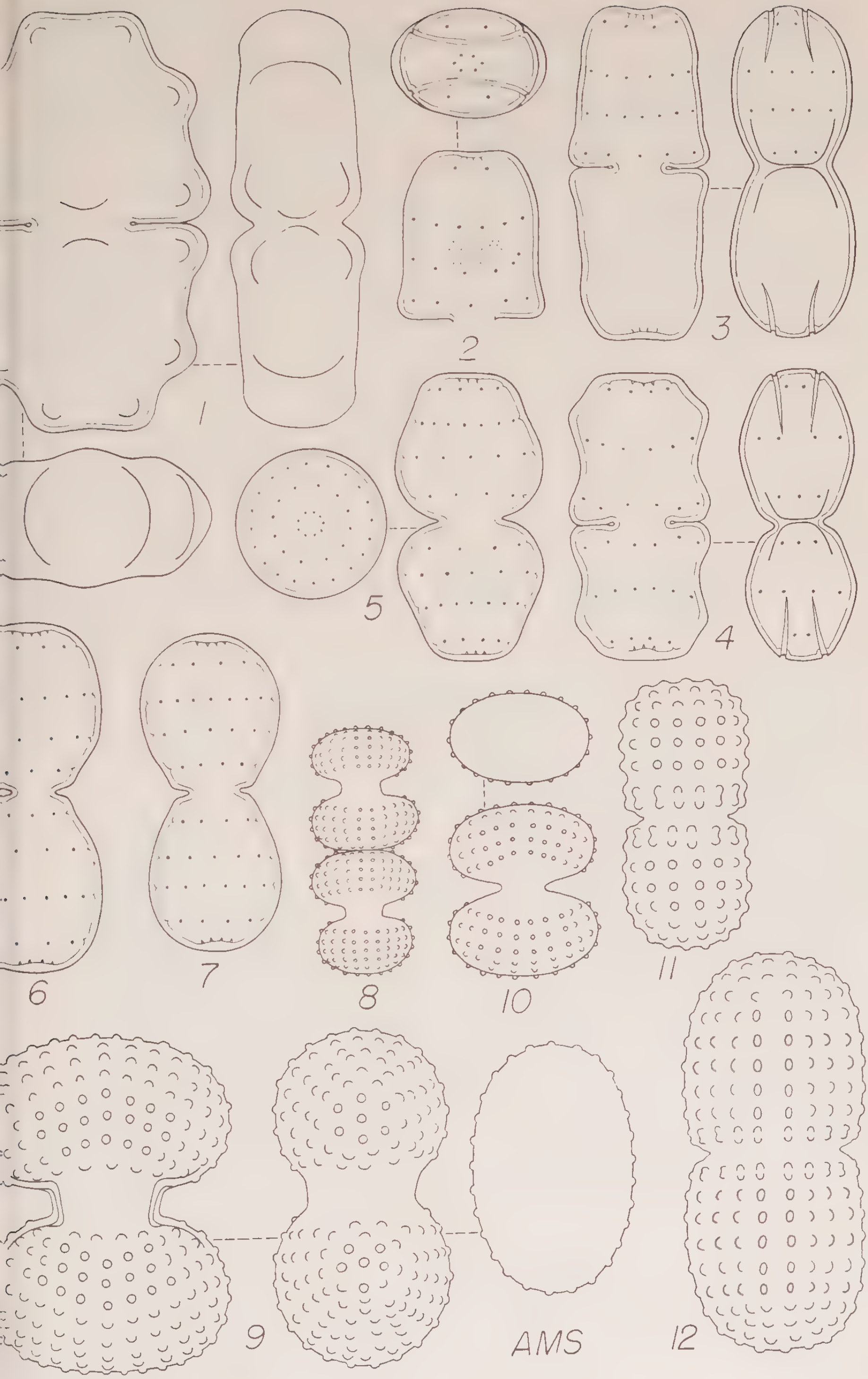


Plate 28

Plate 29.

1, 2. *Cosmarium pardalis* Cohn. Two differing forms from *Cohn*'s original material in WITTROCK & NORDSTEDT's Exsiccatae No. 559, *Desmidiaceae Bongoenses*. x800.

3. *C. scabrum* Turn. x800.

4. *C. margaritatum* (Lund.) Roy & Biss. var. *sublatum* (Nordst.) Krieg. x825.

5. *C. tagmasterion* sp. nov. x800.

6, 7. *C. spinuliferum* West & West 5 x790, 7 x850.

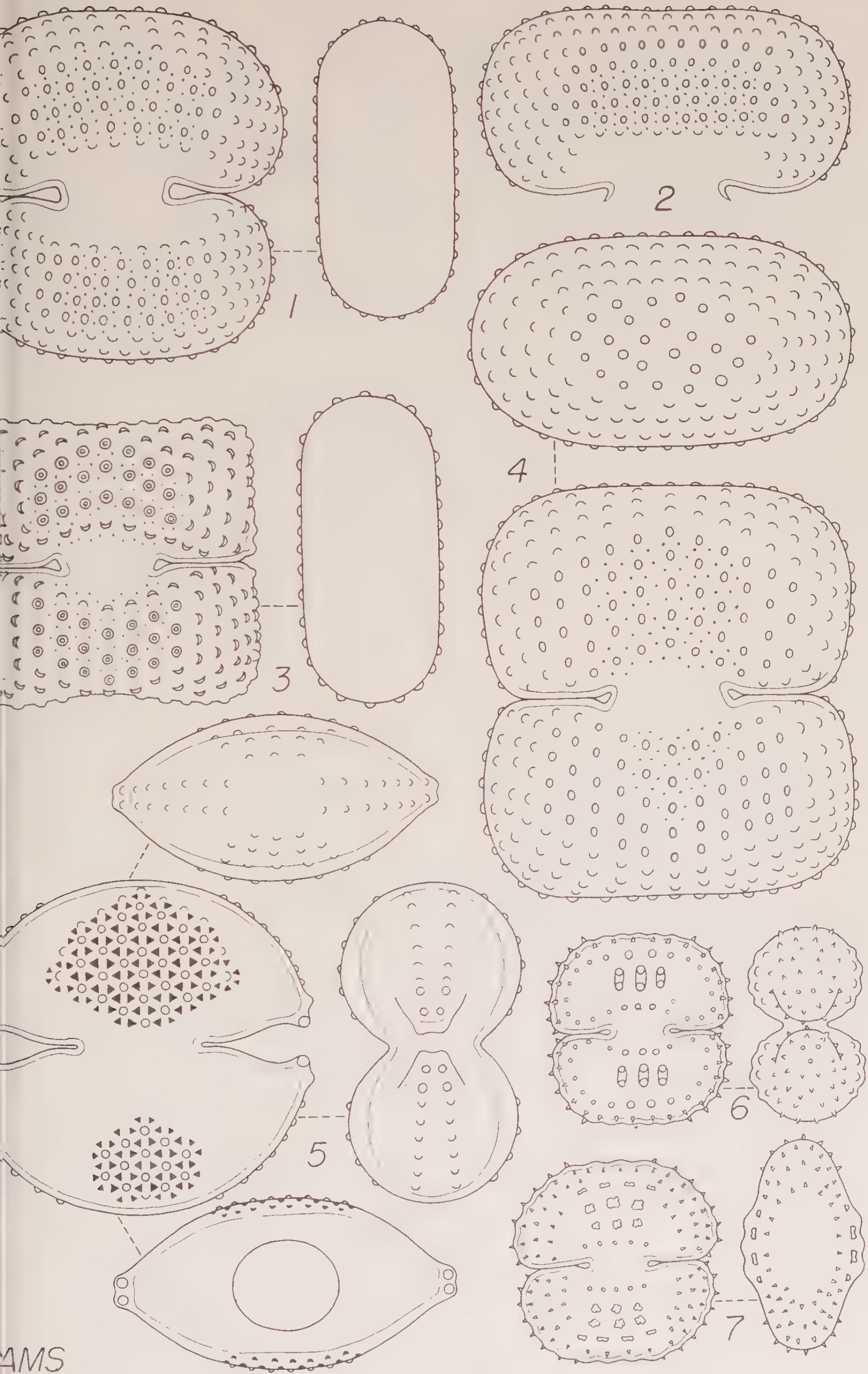


Plate 29

Plate 30.

1, 2. *Cosmarium nudum* (Turn.) Gutw. x800.

3. *C. cuneatum* Josh. x800.

4. *C. crassangulatum* Borge var. *triverrucosum* Krieg. fa. *truncatum* fa. nov. x780.

5. *C. otus* Krieg. var. *ornatum* var. nov. x800.

6. *C. subspeciosum* Nordst. x830.

7. *C. quadriverrucosum* West & West var. *undulatum* var. nov. x1100.

8, 9. *C. burkilli* West & West var. *depressum* var. nov. x850.

10. *C. quadrifarium* Lund. Fa. x800.

11. *C. quadrifarium* Lund. var. *simplex* Krieg. x850.

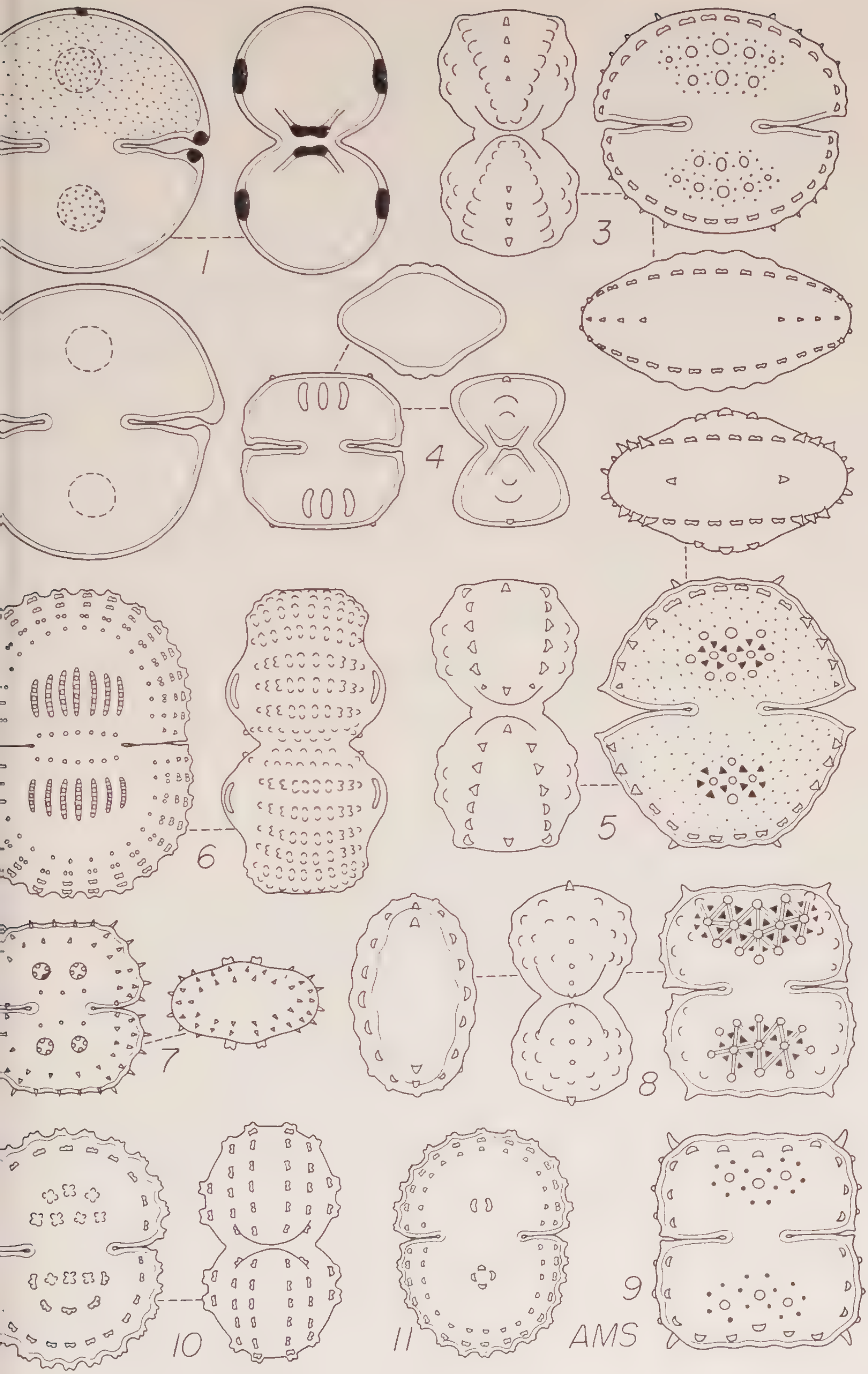


Plate 30

Plate 31.

1, 2. *C. vitiosum* Scott & Grönbl. var. *orientale* var. nov., with zygospore. 1 x840, 2x600.

3, 4. *C. freemanii* West & West var. *verrucosum* var. nov. 3 x830, 4 x800.

5. *C. ceylanicum* West & West fa. *minus* fa. nov. x780.

6. *C. trachypleurum* Lund. var. *nordstetdtii* Gutw. x790.

7. *C. ordinatum* (Börges.) West & West var. *borgei* Scott & Grönbl. x850.

8. *C. punctulatum* Bréb. var. *subpunctulatum* (Nordst.) Börges. Fa. x820.

9. *C. geminatum* Lund. fa. *ornatum* Behre. x830.

10. *C. exasperatum* Josh. x850.

11. *C. exasperatum* Josh. var. *spinatum* var. nov. x800.

12. *C. pseudotaxichondrum* Nordst. var. *siamense* West & West fa. *denticulatum* fa. nov. x800.

13. *C. spyridion* West & West x1150.

14. *C. paucigranulatum* Borge x1150.

15. *C. blyttii* Wille fa. *australicum* Schm. x830.

16. *C. blyttii* Wille var. *novae-silvae* West & West x830.

17. *C. phaseolus* Bréb. var. *omphalum* (Schaarschm.) Racib. x800.

18. *C. apiatum* sp. nov. x800.

19. *C. bioculatum* Bréb. var. *hians* West & West x850.

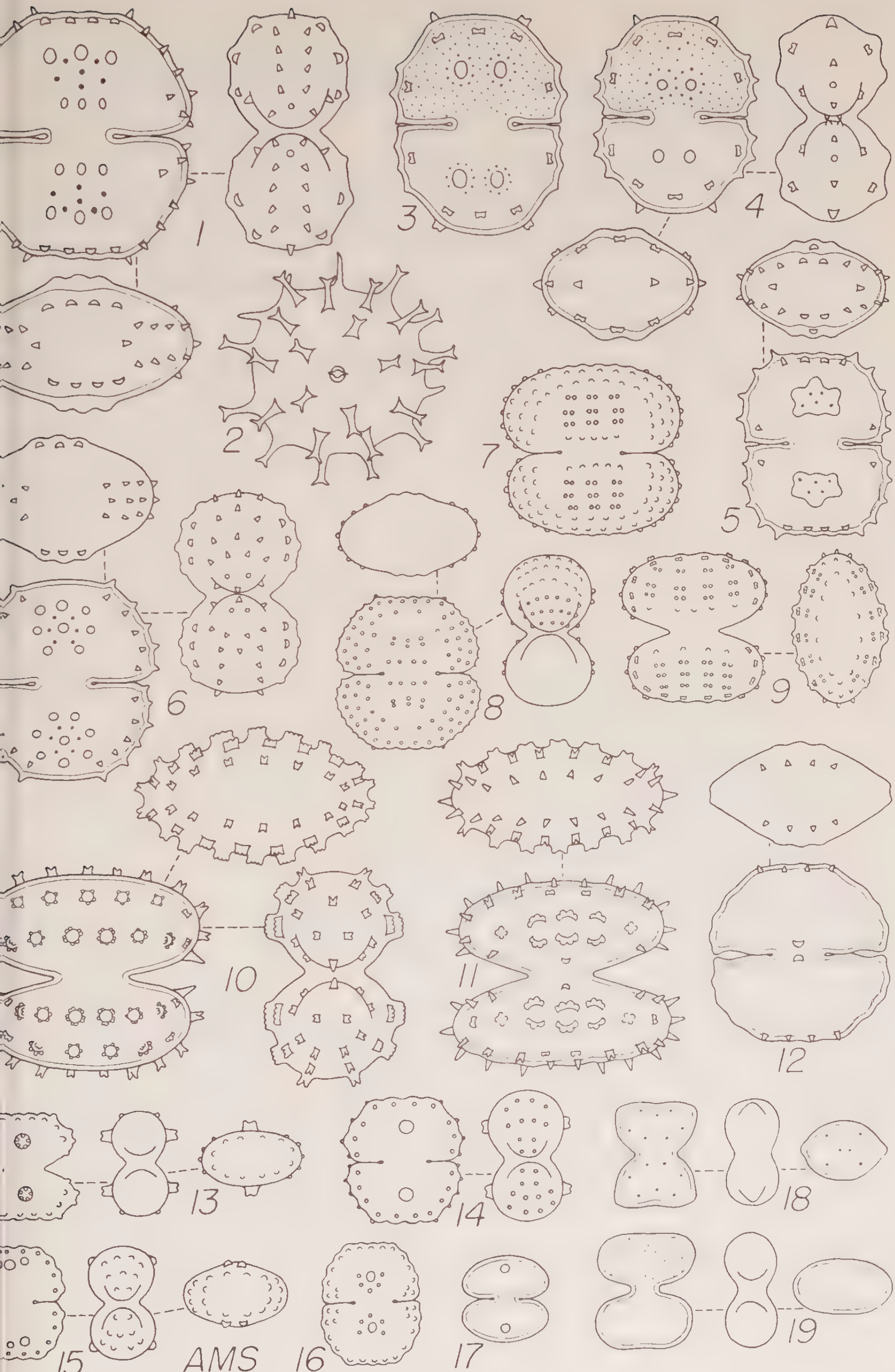


Plate 31

Plate 32.

1, 2. *Cosmarium laeve* Rab. var. *septentrionale* Wille fa. *protuberans* fa. nov. 1 x800, 2 x850.

3. *C. dubium* Borge x780.

4. *C. impressulum* Elfv. fa. *minus* Turn. x810.

5. *C. lunatum* Wolle var. *orientale* var. nov. x750.

6, 7. *C. norimbergense* Reinsch fa. *depressum* West & West x800.

8. *C. pseudoexiguum* Racib. x820.

9. *C. pseudoexiguum* Racib. var. *quadratum* Krieg. x1040.

10. *C. sexangulare* Lund. Fa. x770.

11. *C. sexangulare* Lund. fa. *minimum* Nordst. x750.

12. *C. regnellii* Wille Fa. x800.

13. *C. regnellii* Wille fa. *catenatum* Krieg. x790.

14. *C. regnellii* Wille var. *chondrophorum* Skuja x875.

15. *C. retusiforme* (Wille) Gutw. Fa. x790.

16. *C. subretusiforme* West & West var. *crassum* var. nov. x1100.

17. *C. ocellatum* Eichl. & Gutw. var. *incrassatum* West & West x790.

18. *C. protuberans* Lund. var. *sumatranum* var. nov. x800.

19. *C. sinostegos* Schaarschm. Fa. x1100.

20. *C. sinostegos* Schaarschm. var. *obtusius* Gutw. x1200.

21. *C. malleum* Krieg. var. *menggalense* var. nov. x800.

22. *C. prominulum* Racib. var. *orientale* var. nov. x750.

23. *C. regnesii* Reinsch x1150.

24. *C. regnesii* Reinsch var. *productum* West & West x1150.

25. *C. bireme* Nordst. x790.

26. *C. tinctum* Ralfs fa. *tortum* fa. nov. x1100.

27. *C. tinctum* Ralfs var. *tumidum* Borge x1150.

28. *C. staurastroides* Eichl. & Gutw. var. *porosum* var. nov. x1150.

29. *C. strongylon* sp. nov. x830.

30. *C. pseudoarctoum* Nordst. x1100.

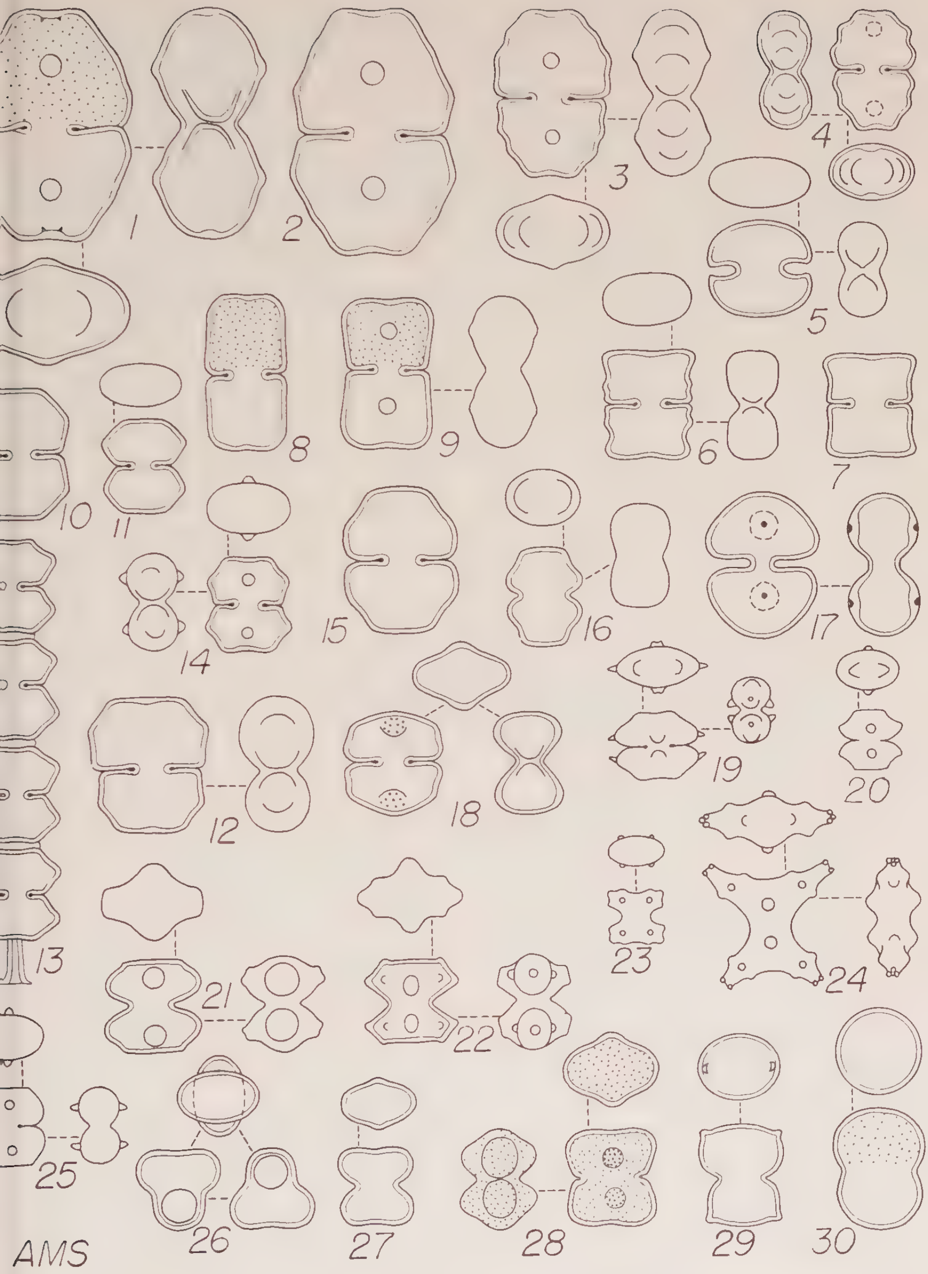
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Plate 32

Plate 33.

1-3. *Arthrodesmus curvatus* Turn. var. *latus* var. nov. x640.

4-8. *A. curvatus* Turn. var. *latus* var. nov. Formae cum spinas supernumerarias. 4-6 x640, 7-8 x480.

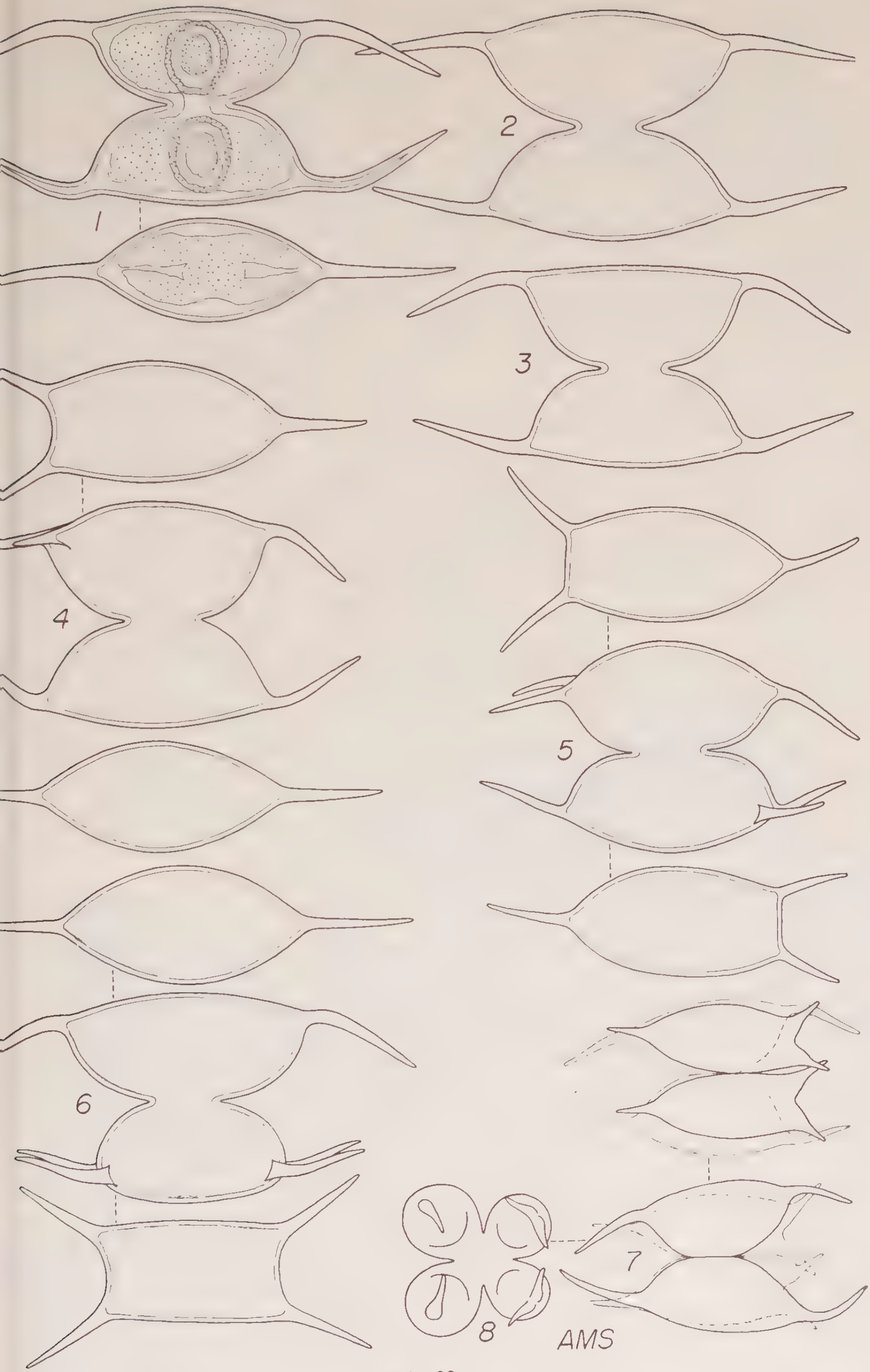


Plate 33

Plate 34.

1. *Arthrodesmus curvatus* Turn. var. *kalimantanus* var. nov. x640.

2, 3. *A. curvatus* Turn. var. *borgei* var. nov. x640.

4. *A. curvatus* Turn. var. *incrassatus* Scott & Presc. x640.

5, 6. *A. convergens* Ehrbg. var. *curtus* Turn. x640.

7-9. *A. convergens* Ehrbg. Three forms from the same collection. x640.

10. *A. convergens* Ehrbg. Fa. x640.

11. *A. apiculatus* Josh. x640.

12. *A. sachlanii* sp. nov. x640.

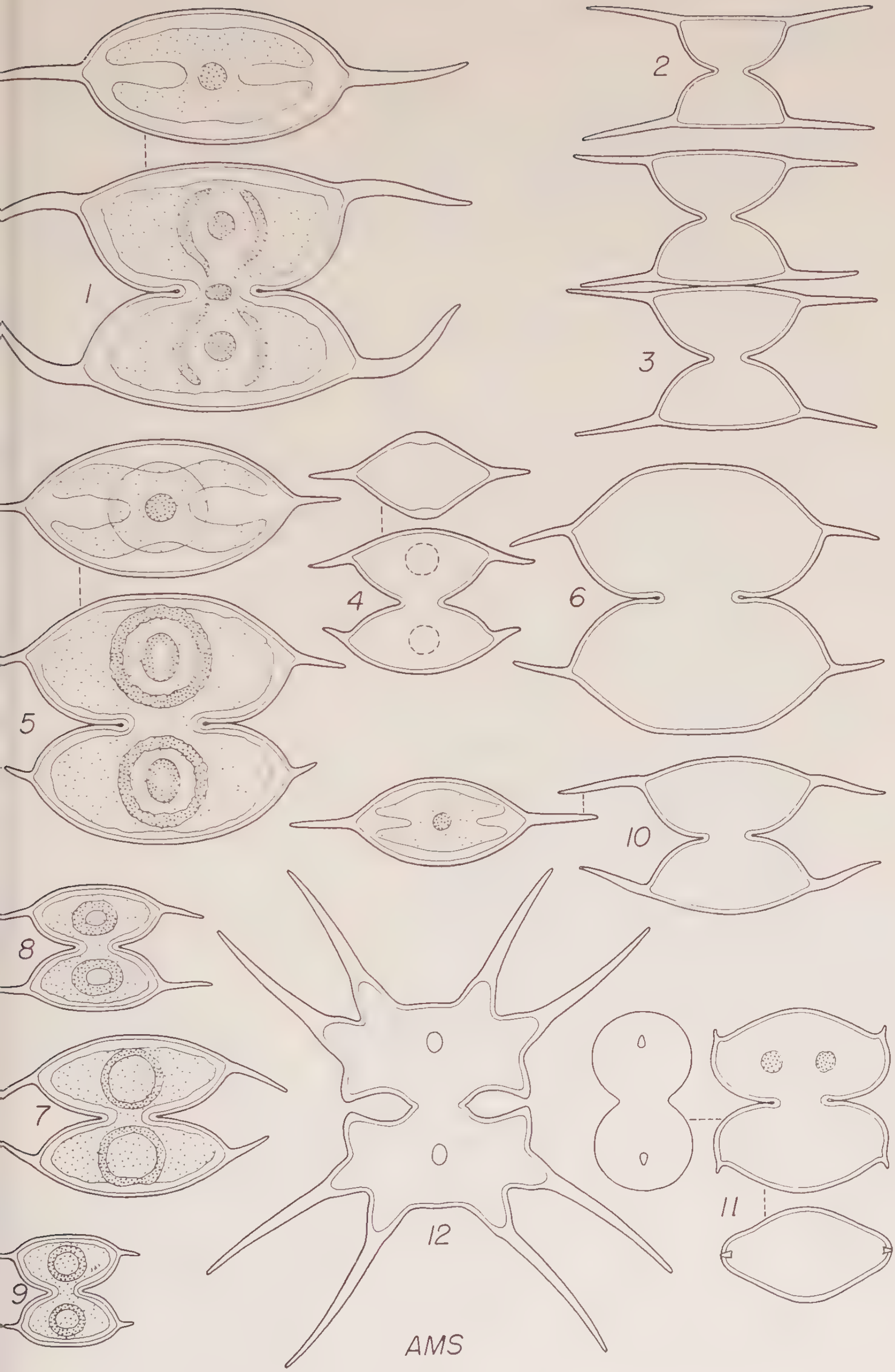


Plate 34

Plate 35.

1. *Arthrodesmus arcuatus* Josh. x800.

2. *A. arcuatus* Josh. var. *incrassatus* var. nov. x800.

3. *A. arcuatus* Josh. var. *minus* var. nov. x780.

4, 5. *A. subvalidus* Grönbl. x780.

6. *A. gibberulus* Josh. x800.

7. *A. gibberulus* Josh. Fa. x780.

8. *A. crassus* West & West Fa. x800.

9-12. *A. octocornis* Ehrbg. x800.

13. *A. bifidus* Bréb. Fa. x1180.

14. *A. spechtii* Scott & Presc. x800.

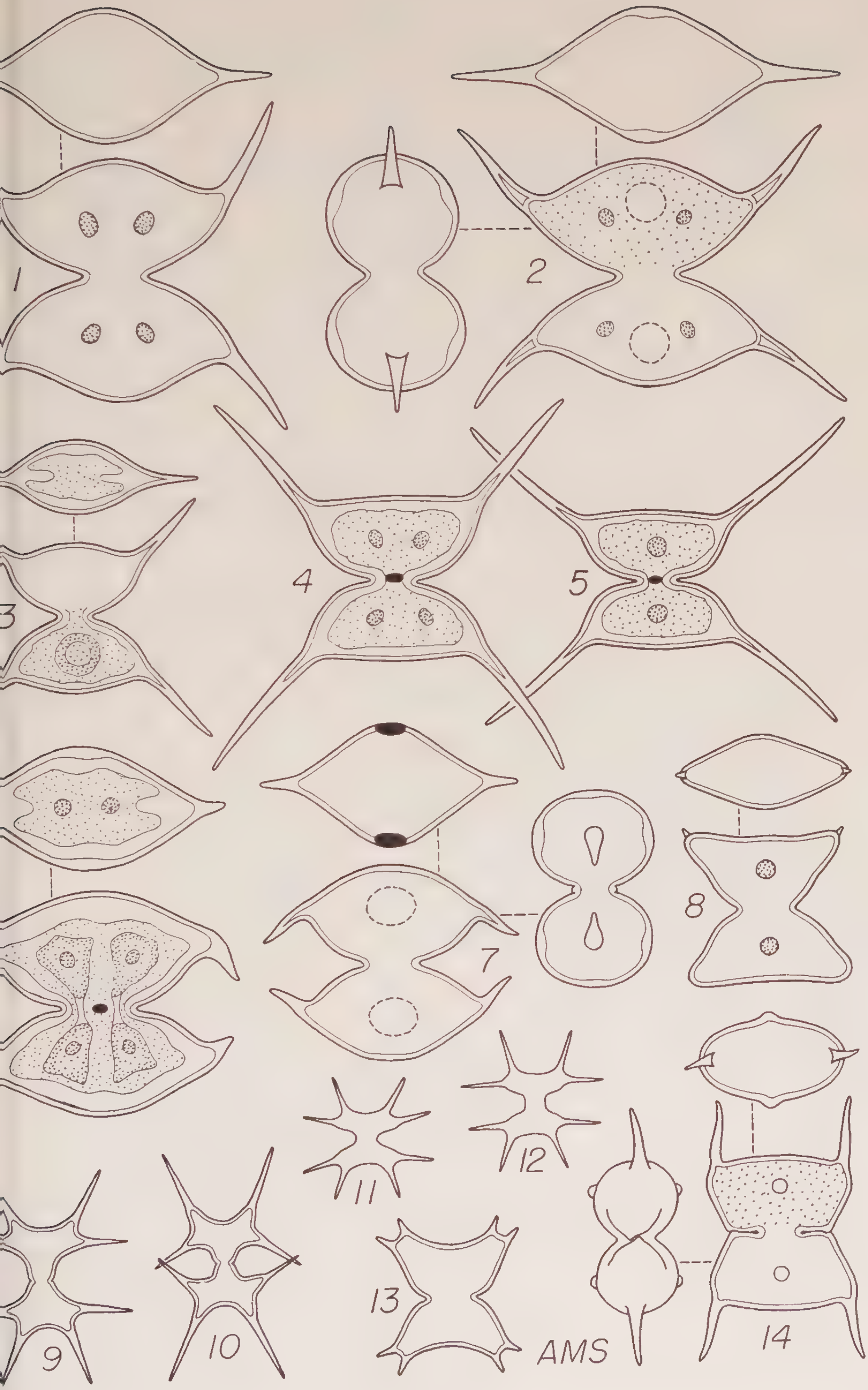


Plate 35

Plate 36.

1. *Arthrodesmus incus* (Bréb.) Hass. var. *extensus* Anderss. x780.

2. *A. constrictus* G. M. Smith var. *longispinus* Grönbl. x780.

3, 4. *A. sumatranus* sp. nov. x750.

5, 6. *A. psilosporus* (Nordst. & Löfg.) De Toni. Formae. x800.

7. *A. menoides* sp. nov. x800.

8. *Xanthidium lepidum* West & West x780.

9. *X. lepidum* West & West Fa. x780.

10. *X. lepidum* West & West var. *reversum* var. nov. x780.

11. *X. horridum* Skuja var. *decoratum* var. nov. x810.

12. *X. acanthophorum* Nordst. var. *raciborskii* Gutw. x800.

13. *X. concinnum* Arch. Fa. x1080.

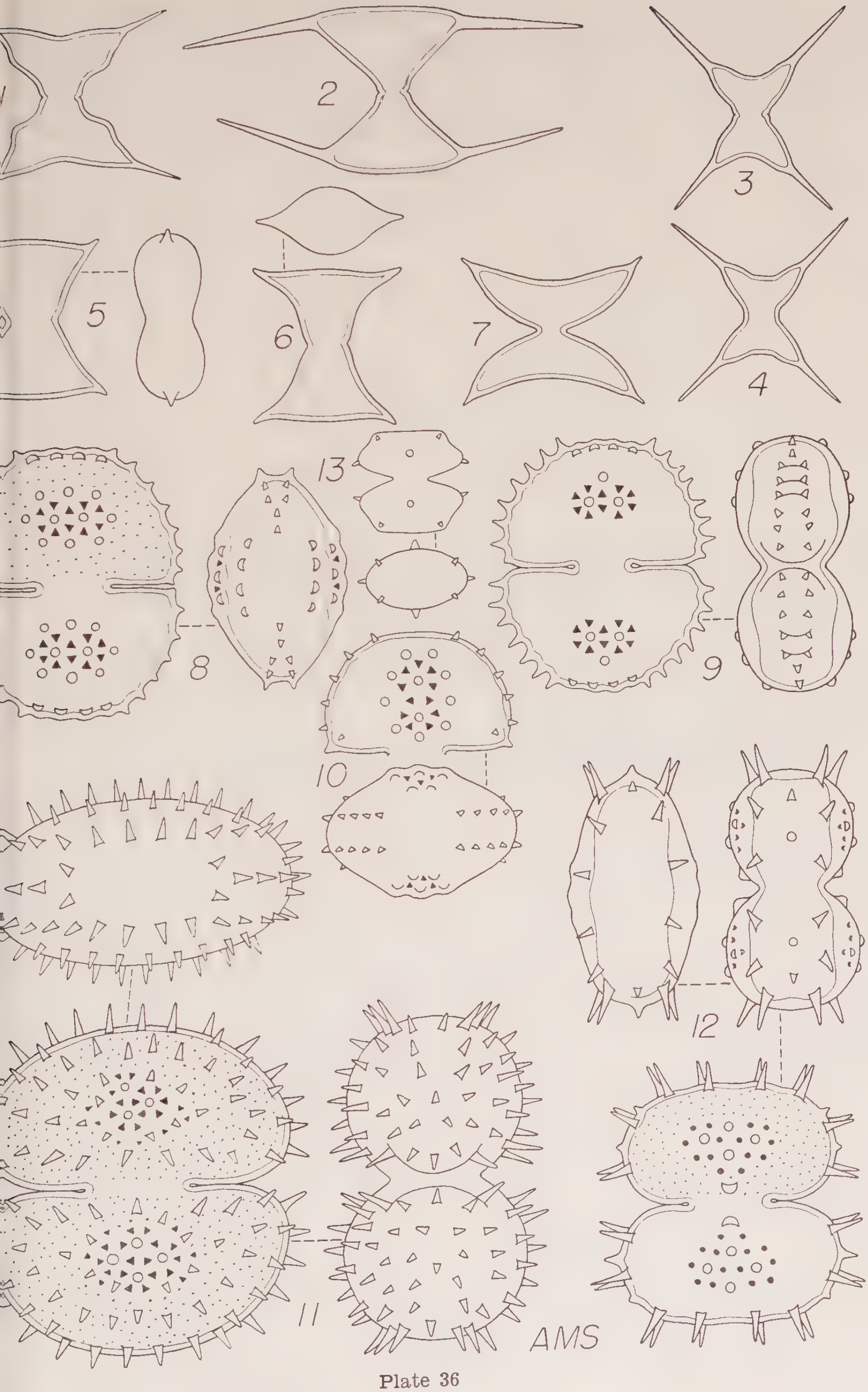


Plate 36

Plate 37.

1. *Xanthidium acanthophorum* Nordst. var. *raciborskii* Gutw. x640.

2, 3. *X. spinosum* (Josh.) West & West Fa. x660.

4. *X. freemanii* West & West Fa. x470.

5. *X. superbum* Elfv. x630.

6, 7. *X. sansibarense* Hier. fa. *asymmetricum* fa. nov. x620.

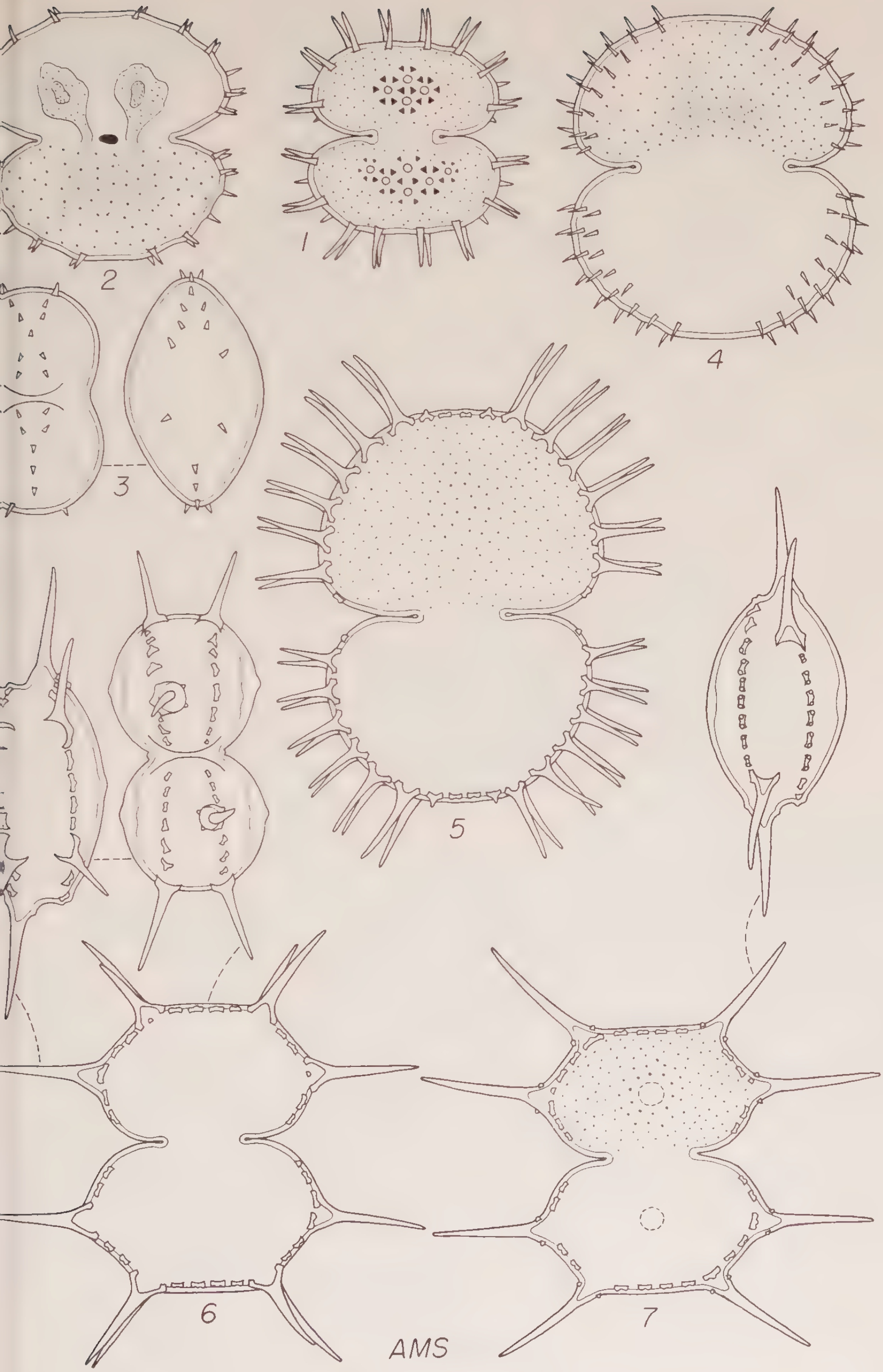


Plate 37

Plate 38.

1. *Xanthidium antilopaeum* (Bréb.) Kütz. fa. *javanicum* Nordst. x485.

2. *X. antilopaeum* (Bréb.) Kütz. var. *laeve* Schm. fa. *longispinum* fa. nov. x470.

3. *X. antilopaeum* (Bréb.) Kütz. var. *laeve* Schm. fa. *minus* fa. nov. x650.

4, 5. *X. subtrilobum* West & West var. *inornatum* Skuja x650.

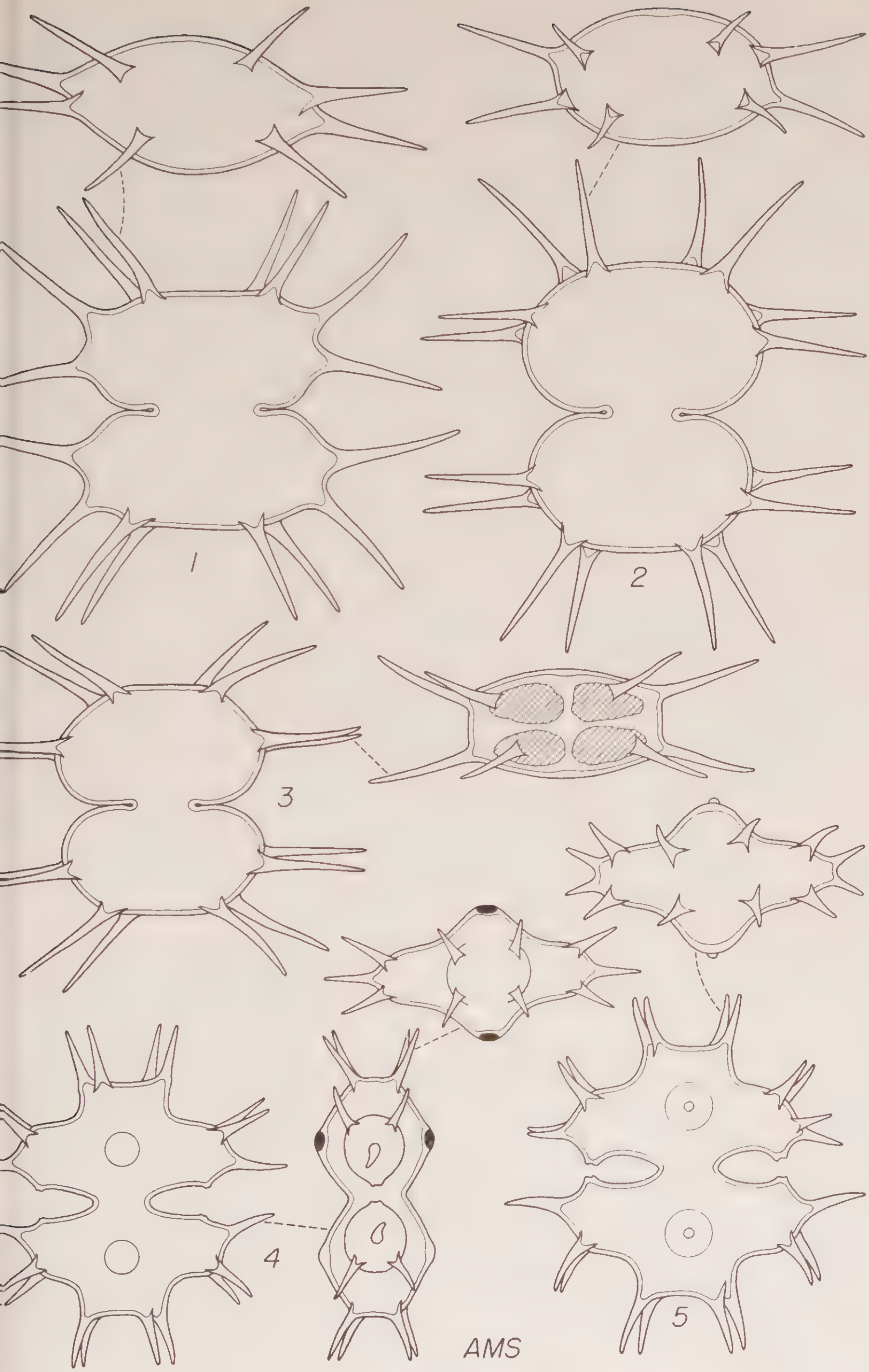


Plate 38

Plate 39.

1. *Xanthidium subtrilobum* West & West x640.

2. *X. sexmamillatum* West & West var. *pulneyense* Iyengar & Bai x640.

3. *X. calcarato-aculeatum* (Hier.) Schm. x640.

4,5. *X. armatum* (Bréb.) Rab. var. *anguligerum* Krieg. Formae. 4 x480, 5 x375

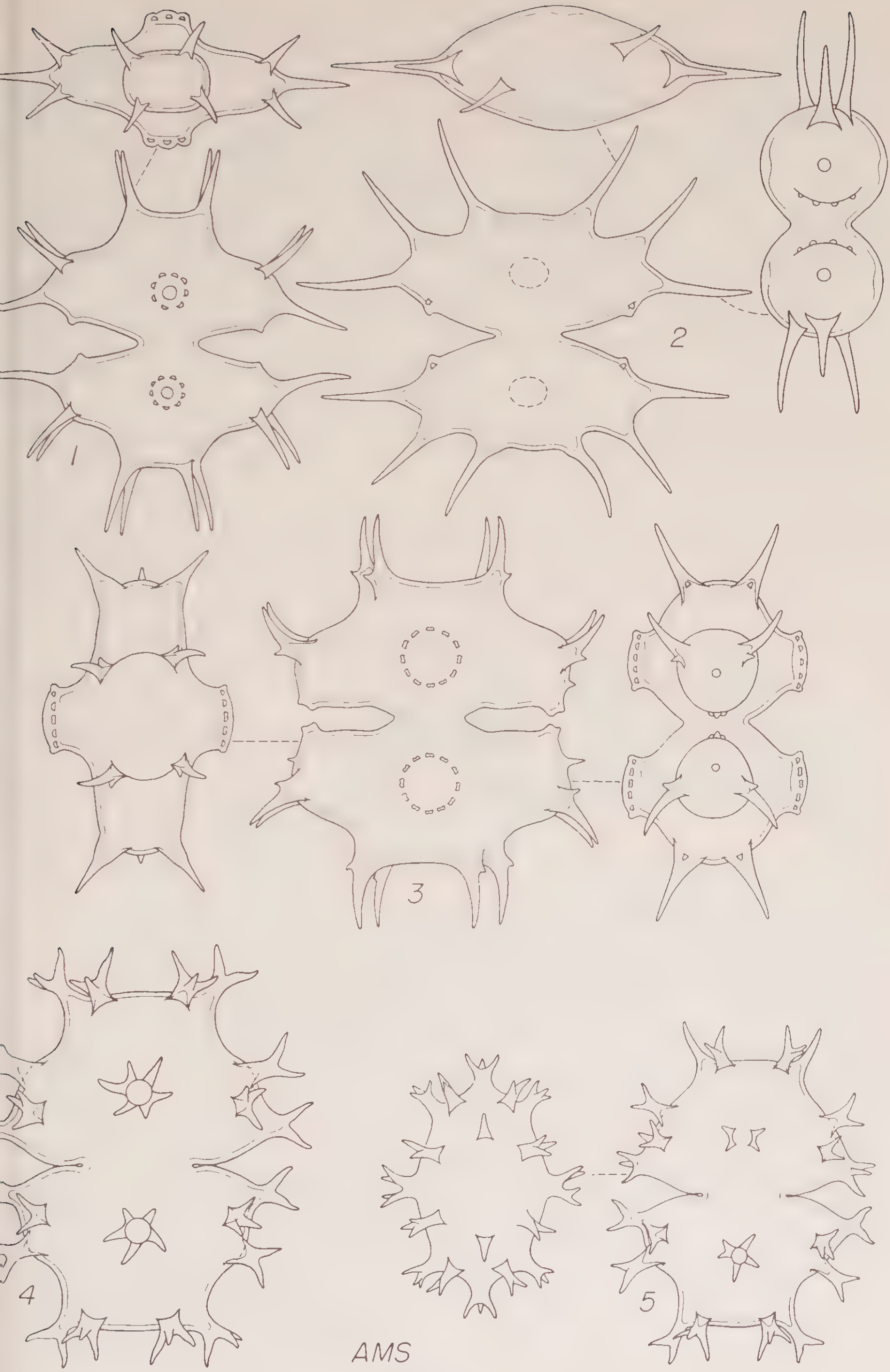


Plate 39

Plate 40.

1. *Xanthidium burkillii* West & West x640.

2. *X. burkillii* West & West var. *alternans* Skuja x640.

3, 4. *X. hastiferum* Turn. x640.

5. *X. hastiferum* Turn. var. *javanicum* (Nordst.) Turn. fa. *planum* Turn. x640.

6. *X. kalimantanum* sp. nov. x640.

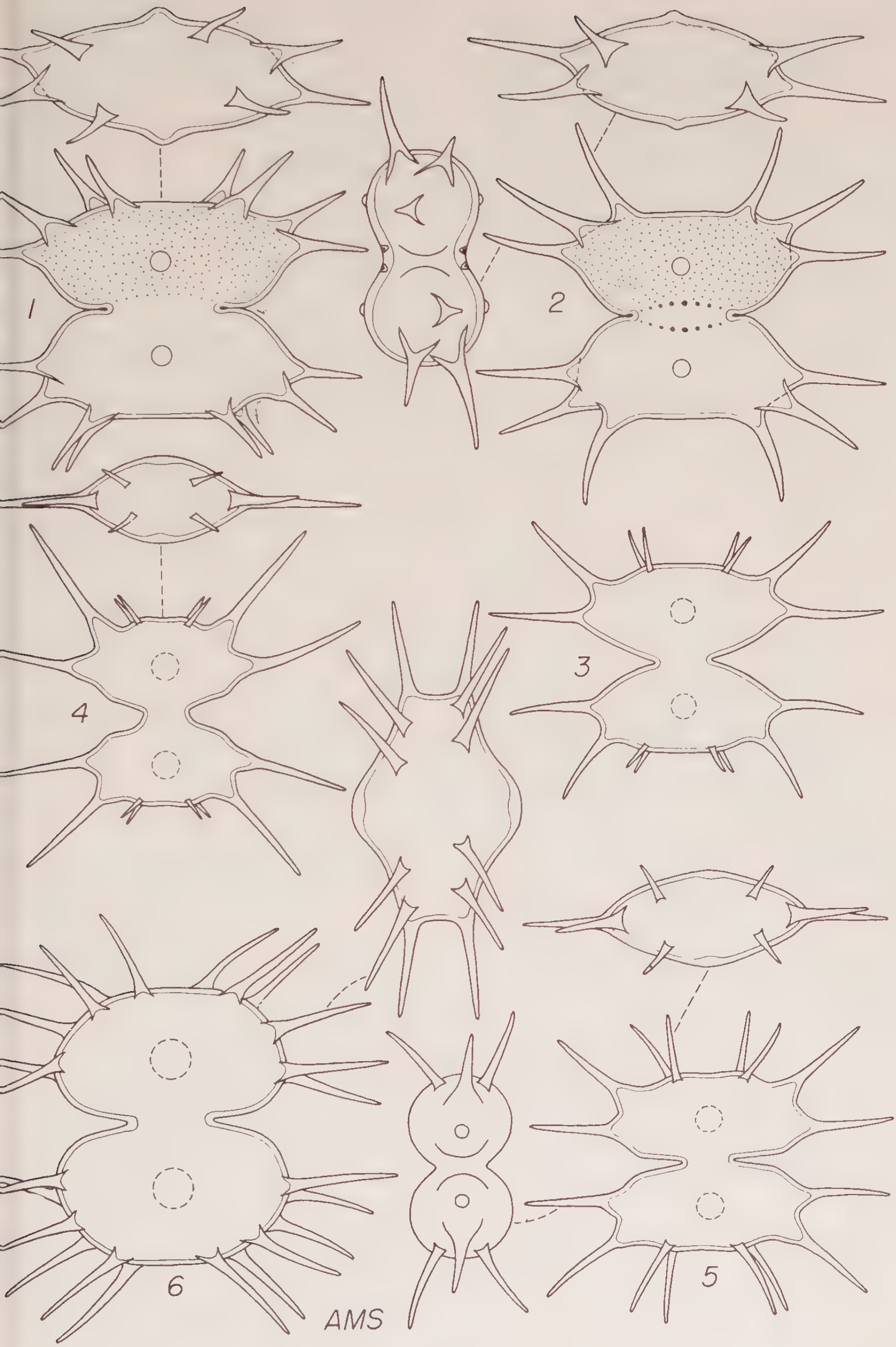


Plate 40

Plate 41.

1, 2. *Xanthidium perissacanthum* sp. nov. x480.

3. *X. perissacanthum* Scott & Presc. var. *minus* var. nov. x480.

4. *Staurastrum curvatum* W. West Fa. x680.

5. *St. dickei* Ralfs fa. *longispinum* Fritsch & Rich x650.

6. *St. prainii* West & West fa. *rotundum* fa. nov. x625.

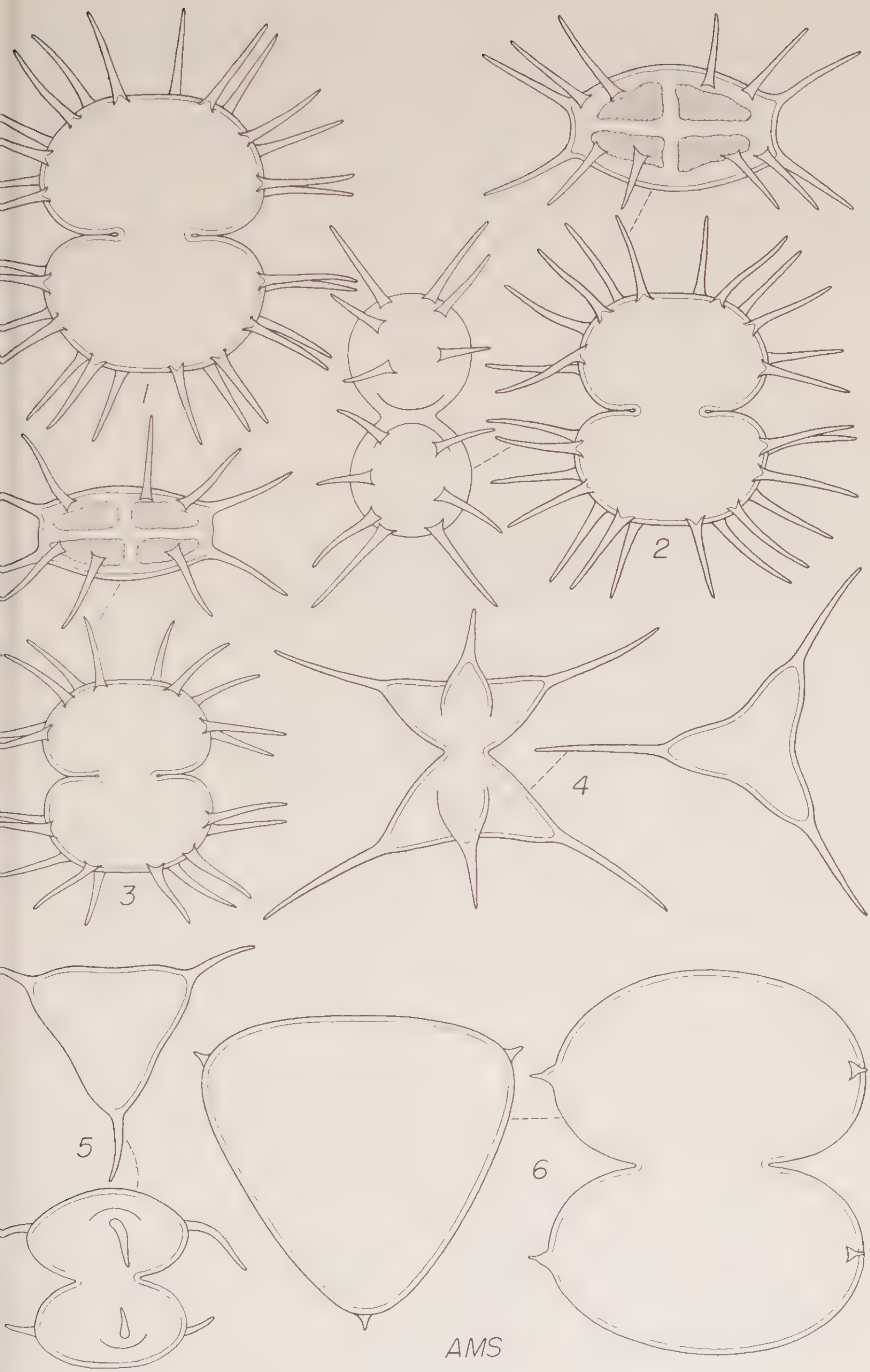


Plate 41

Plate 42.

1. *Staurastrum acanthastrum* West & West x620.

2, 3. *St. limneticum* Schm. var. *burmense* West & West 2 x600, 3 x500.

4. *St. pentacrinum* Krieg. x640.

5. *St. thienemannii* Krieg. fa. *triradiatum* fa. nov. x680.

6. *St. thienemannii* Krieg. var. *calvum* var. nov. x625.

7. *St. „hexops"* sp. nov.? x640.

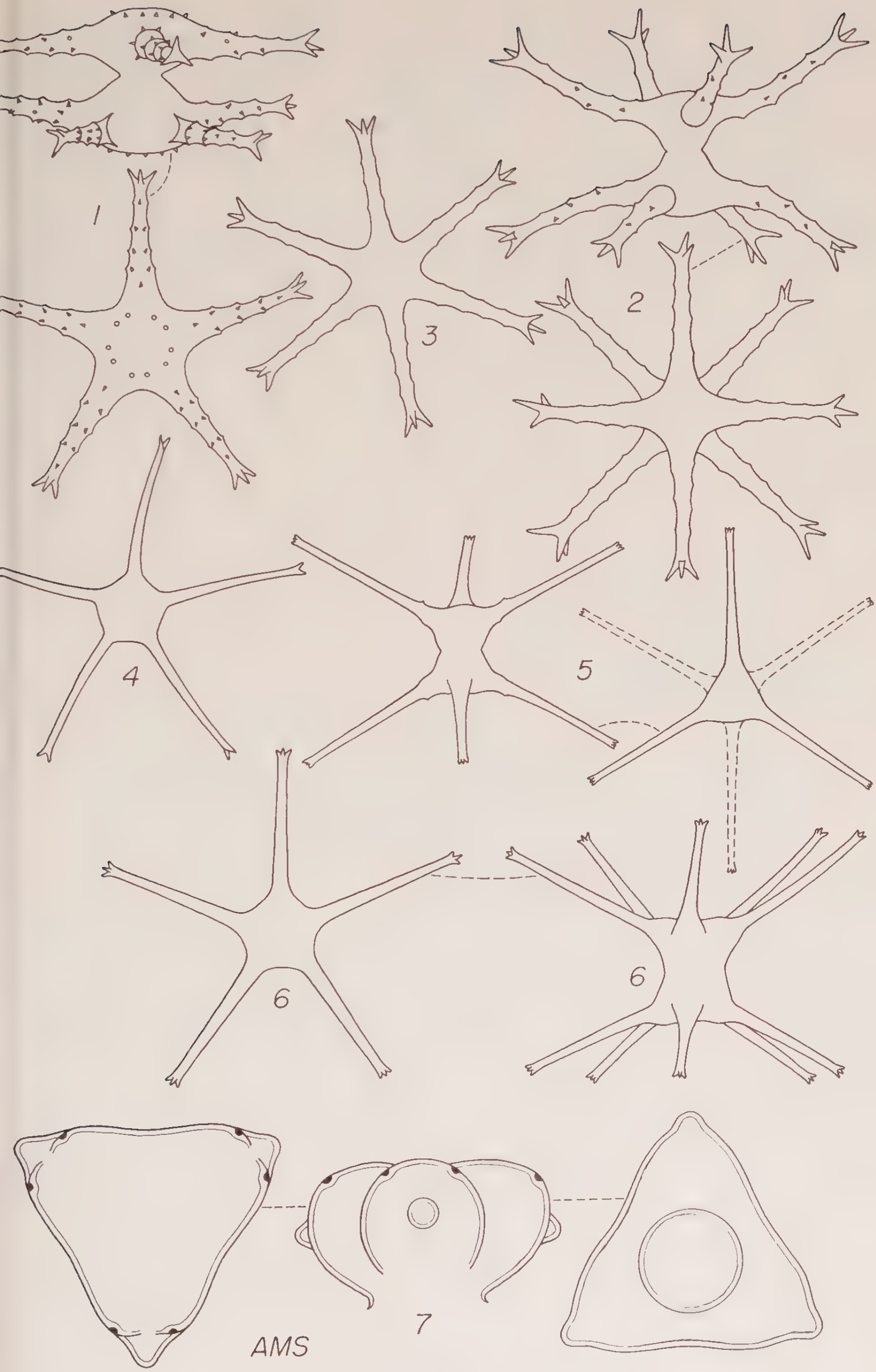


Plate 42

Plate 43.

1. *Staurastrum freemanii* West & West x640.

2. *St. freemanii* West & West var. *triquetrum* West & West x640.

3. *St. freemanii* West & West var. *nudiceps* Scott & Presc. x640.

4. *St. freemanii* West & West var. *nudiceps* Scott & Presc. fa. *biradiatum* Scott & Presc. x640.

5. *St. freemanii* West & West var. *evolutum* Scott & Presc. x640.

6. *St. gutwinskii* Bern. var. *brevispinum* var. nov. x640.

7. *St. gutwinskii* Bern. var. *evolutum* var. nov. x640.

8-10. *St. formosum* Bern. Formae. x640.

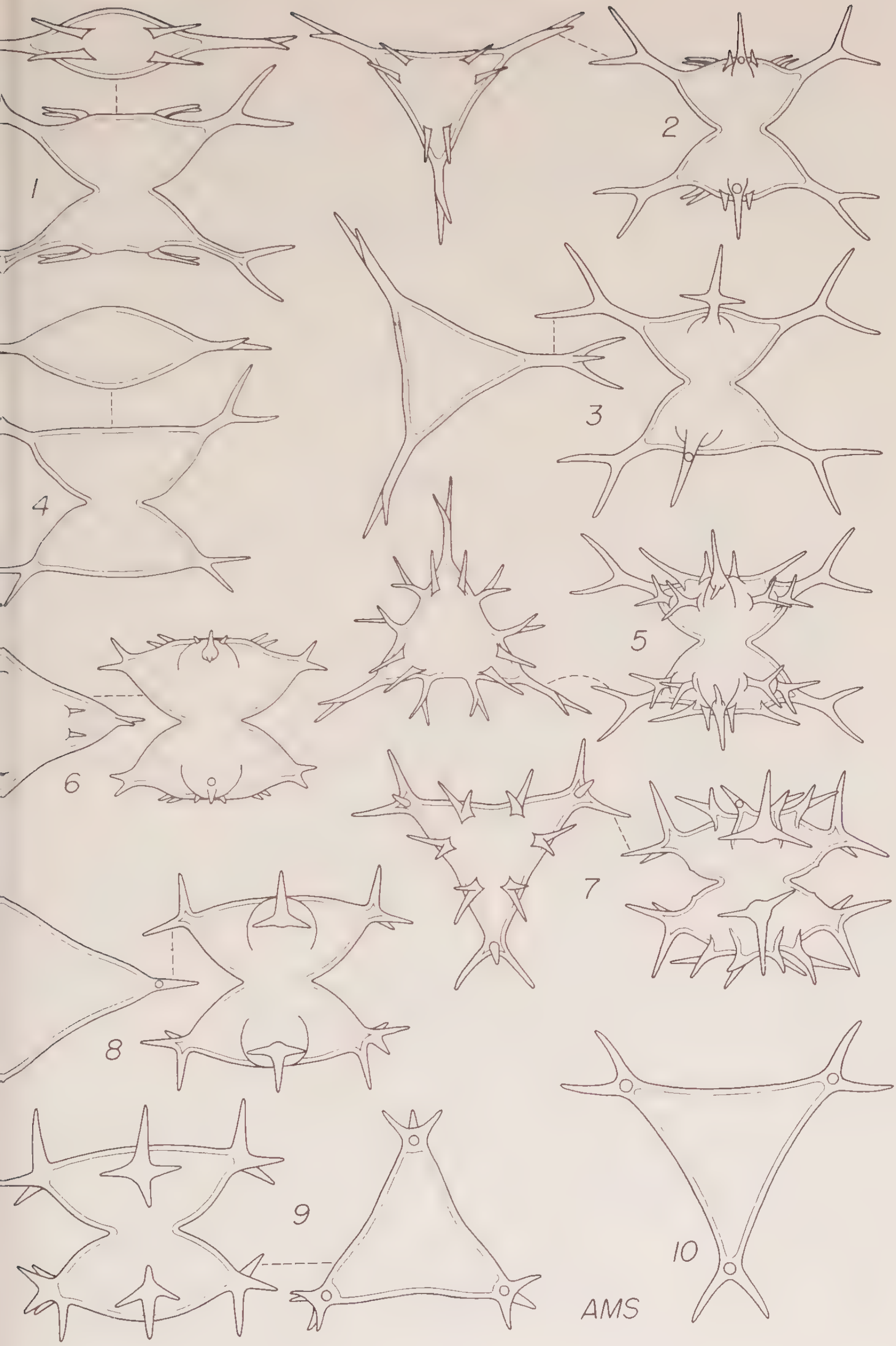


Plate 43

Plate 44.

1, 2. *Staurastrum protectum* West & West var. *rangoonense* (Skuja) Scott & Presc. comb. nov. x640.

3. *St. spinipendens* sp. nov. x640.

4. *St. sebaldi* Reinsch var. *ornatum* Nordst. x640.

5. *St. sebaldi* Reinsch var. *ventriverrucosum* var. nov. x640.

6. *St. javanicum* (Nordst.) Turn. var. *apiculiferum* (Turn.) Krieg. x640.

7. *St. multispiniceps* sp. nov. x640.

8. *St. zahlbruckneri* Lütkem. var. *mamillatum* West & West x500.

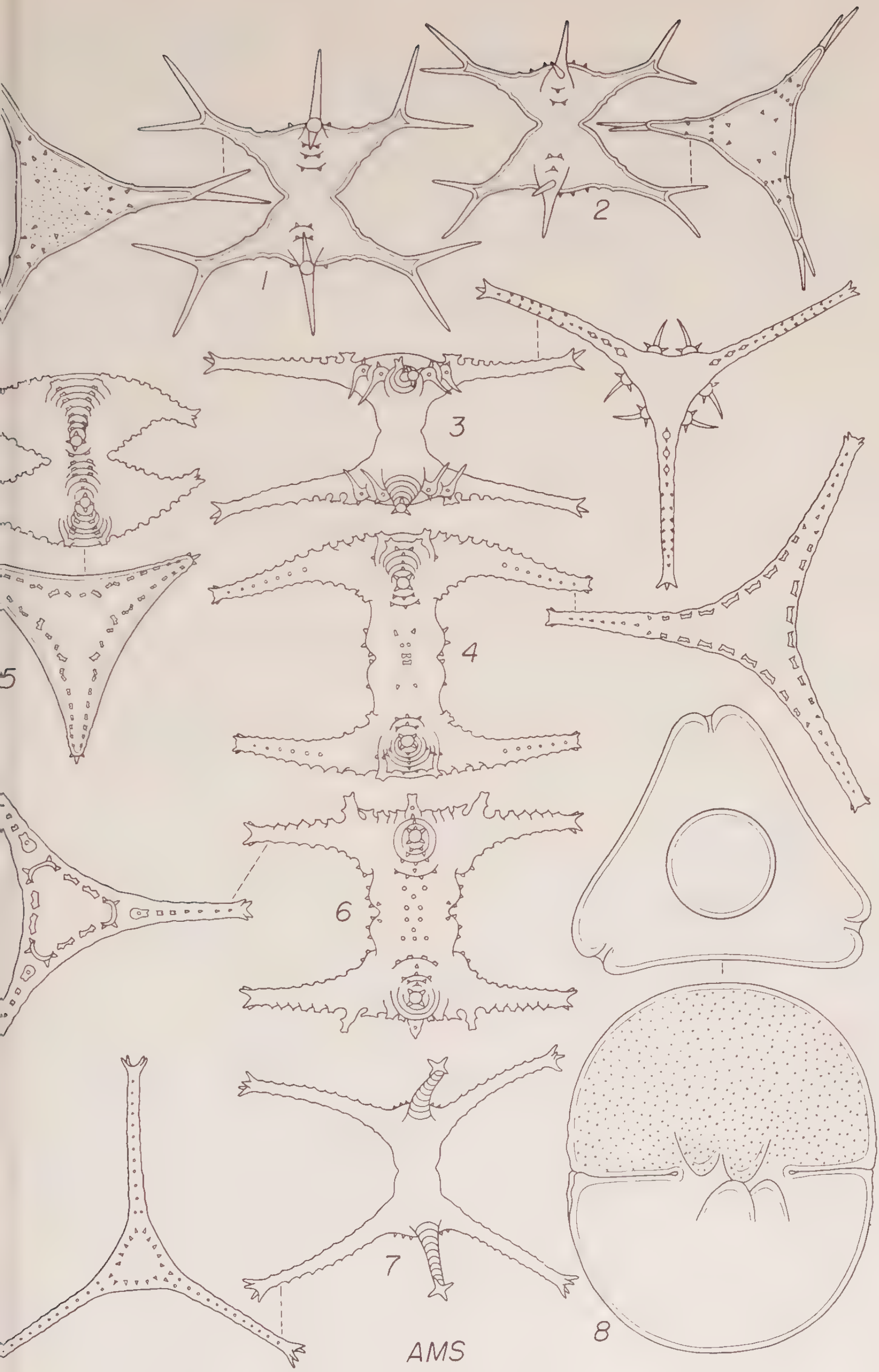


Plate 44

Plate 45.

1-3. *Staurastrum sexangulare* Lund. var. *asperum* Playf. x460.

4, 5. *St. sexangulare* Lund. var. *bidentatum* Gutw. x480.

6, 7. *St. sexangulare* Lund. var. *bidentatum* Gutw. fa. *crassum* fa. nov. x640.

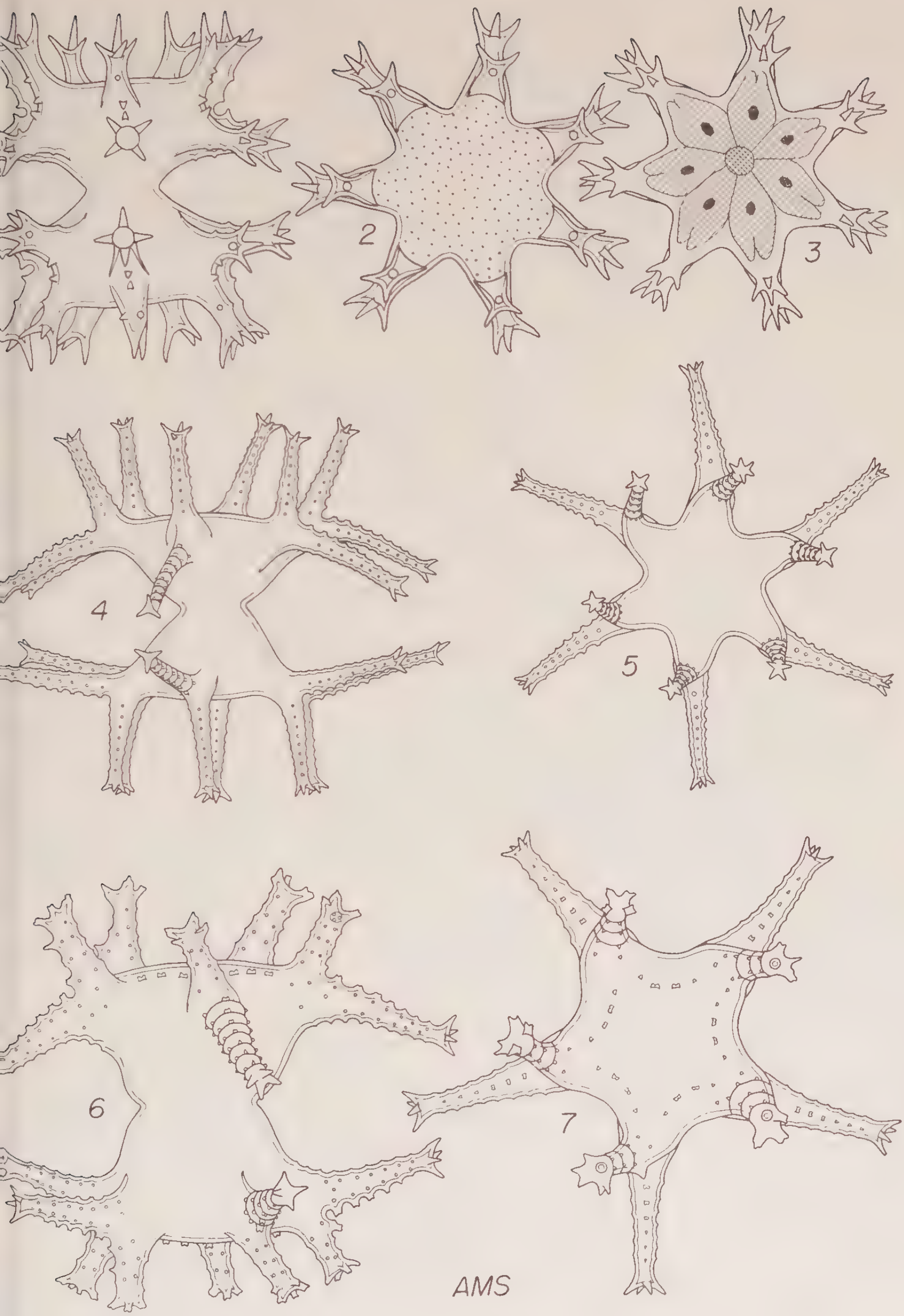


Plate 45

Plate 46.

1. 2. *Staurastrum sexangulare* Lund. var. *subglabrum* West & West x620.

3, 4. *St. sexangulare* Lund. var. *productum* Nordst. x640.

5. *St. sexangulare* Lund. var. *attenuatum* Turn. x660.

6. *St. sexangulare* Lund. Fa. x600.

7. *St. pinnatum* Turn var. *hydra* Krieg. fa. *supernumerarium* fa. nov. x620.

8. *St. zonatum* Börges. var. *majus* var. nov. x650.

9, 10. *St. pinnatum* Turn. var. *subpinnatum* (Schm.) West & West fa. *robustum* Krieg. x640.

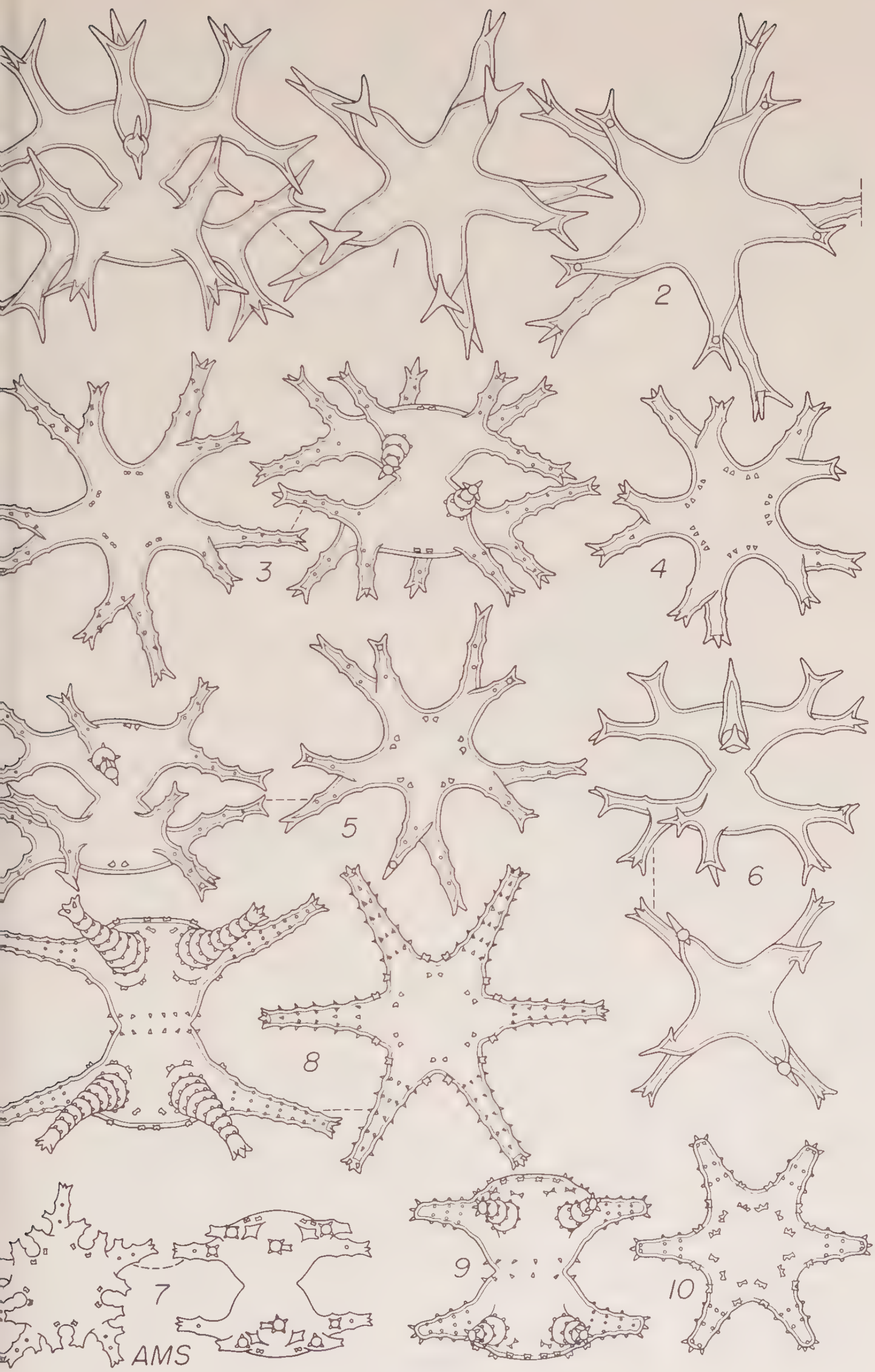


Plate 46

Plate 47.

1-4. *Staurastrum tauphorum* West & West. Two differing forms from the same collection, Sumatra 115. x480.

5-6. *St. tauphorum* West & West. Two forms from the same collection, Borneo 134. x480.

7. *St. tauphorum* West & West. A new quadriradiate form, Borneo 213. x480.

8-11. *St. tauphorum* West & West. Differing forms of the supraisthmian processes. 8-10 x480, 11 x540.

12-15. *St. tohopekaligense* Wolle var. *insigne* West & West. Formae. x480.

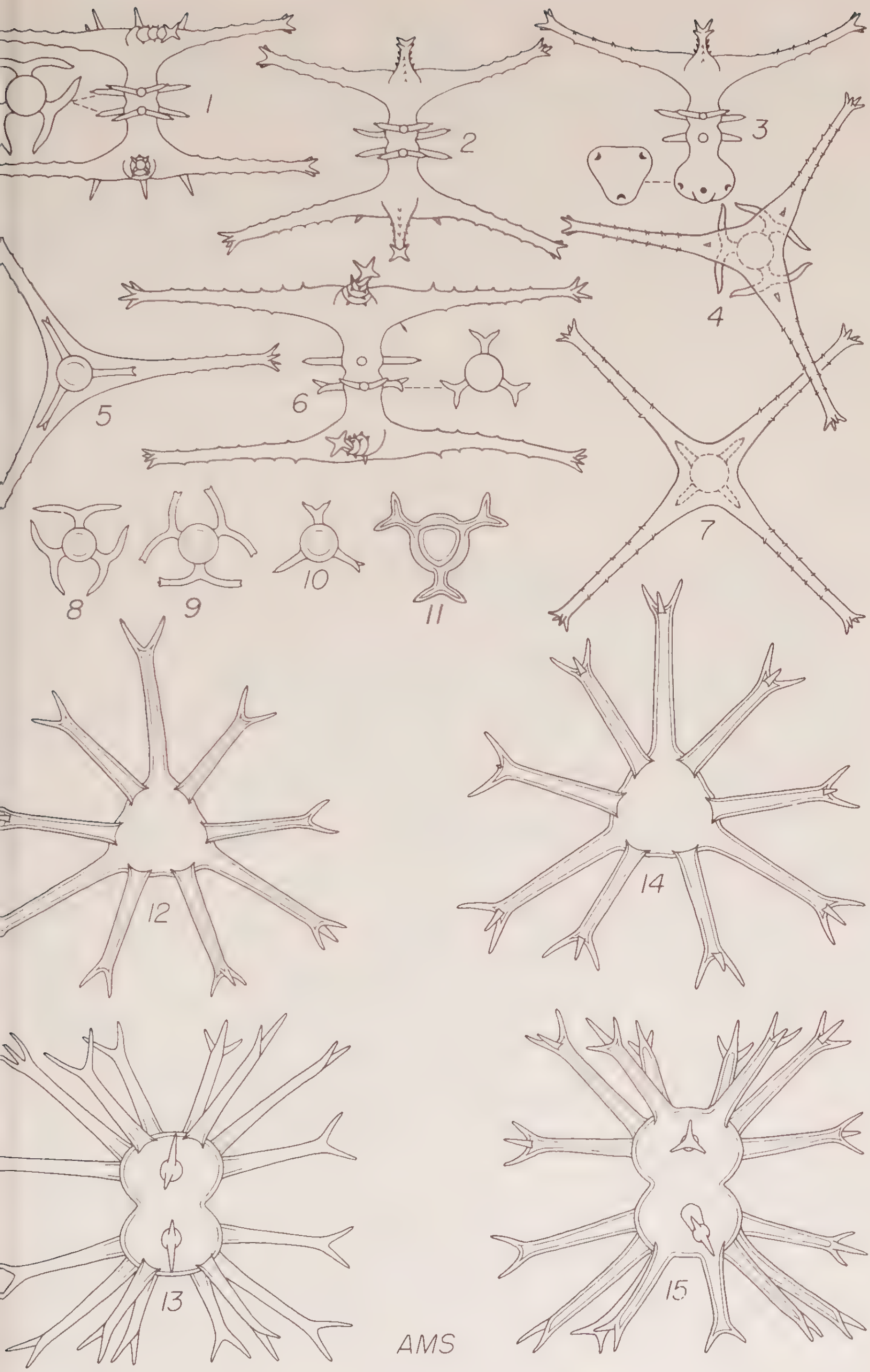


Plate 47

Plate 48.

1. *Staurastrum tohopekaligense* Wolle var. *robustum* var. nov. x640.

2. *St. tohopekaligense* Wolle var. *trifurcatum* West & West x480.

3. *St. tohopekaligense* Wolle fa. *acuminatum* fa. nov. x620.

4-6. *St. tohopekaligense* Wolle fa. *minus* (Turn.) Scott & Presc. comb. nov. x640.

7, 8. *St. zonatum* Börges. var. *majus* var. nov. x640.

9. *St. zonatum* Börges. var. *ceylanicum* West & West x640.

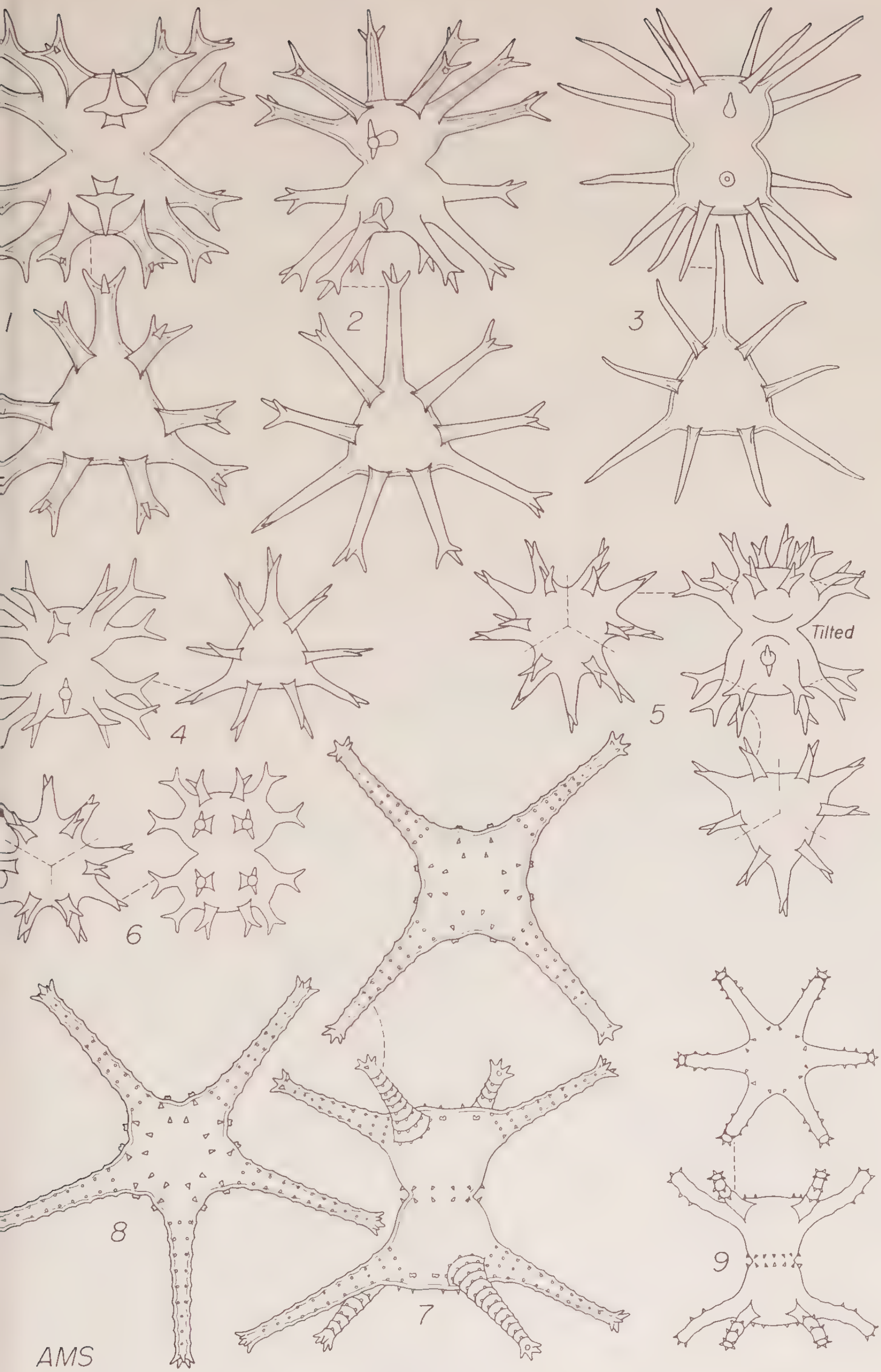


Plate 48

Plate 49.

1. *Staurastrum wildemanii* Gutw. x490.

2. *St. wildemanii* Gutw. var. *majus* (West & West) Scott & Presc. x490.

3. *St. wildemanii* Gutw. var. *horizontale* Scott & Presc. x480.

4. *St. wildemanii* Gutw. var. *unispiniferum* Scott & Presc. x480.

5. *St. hypacanthum* sp. nov. x600.

6. *St. tripyrenoideum* sp. nov. x460.

7, 8. *St. orbiculare* Ralfs var. *denticulatum* Nordst. x640.

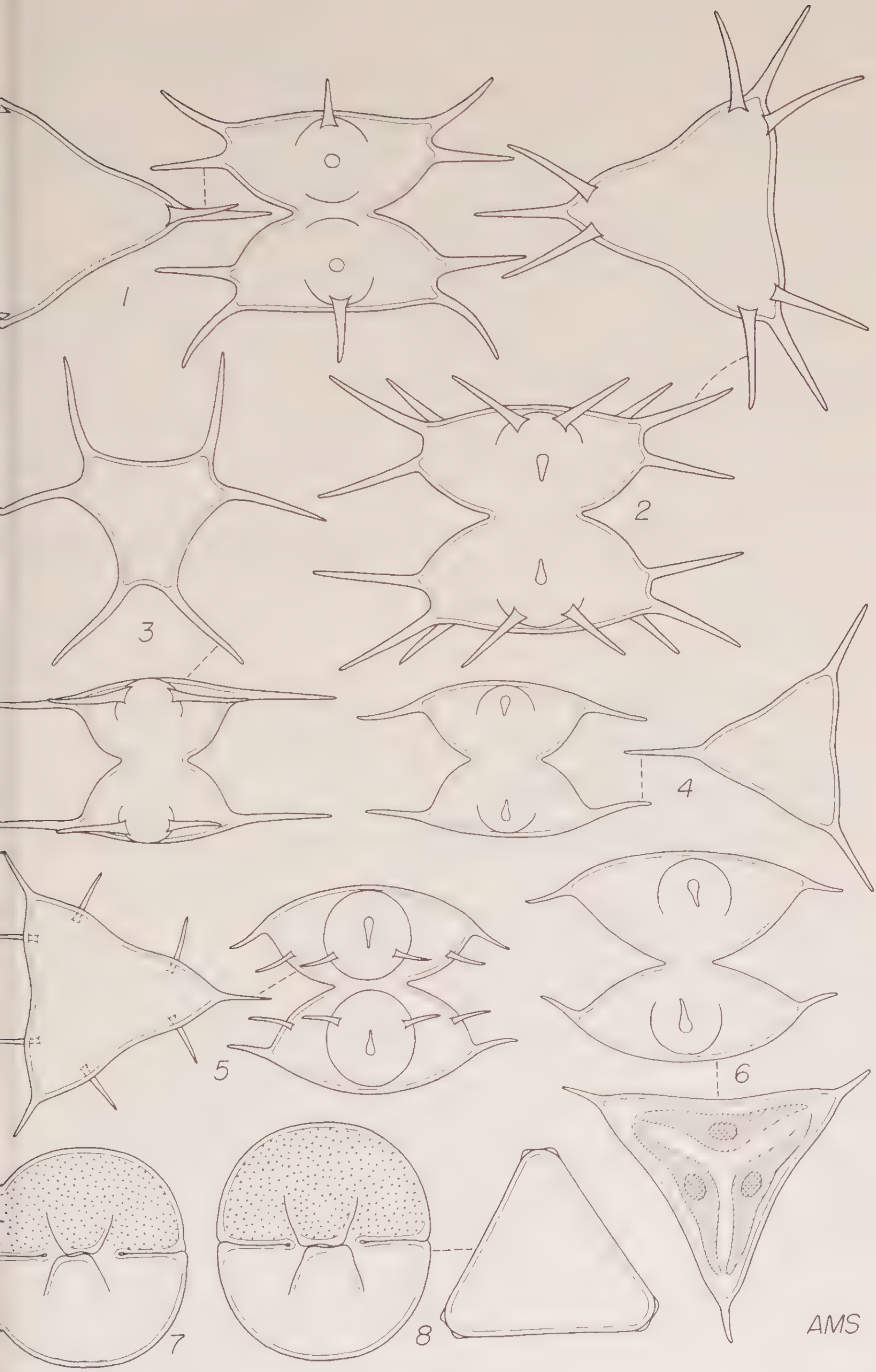


Plate 49

Plate 50.

1-3. *Staurastrum columbetoides* West & West var. *basiaculeatum* var. nov. 1 x680, 2 x890, 3 x1000.

4. *St. exporrectum* sp. nov. x640.

5. *St. longebrachiatum* (Borge) Gutw. x640.

6, 7. *St. indentatum* West & West Formae. x640.

8, 9. *St. indentatum* West & West fa. *minus* fa. nov. x700.

10. *St. prionotum* sp. nov. x640.

11. *St. prionotum* sp. nov. Janus-form combining bi- and triradiate semicells. x640.

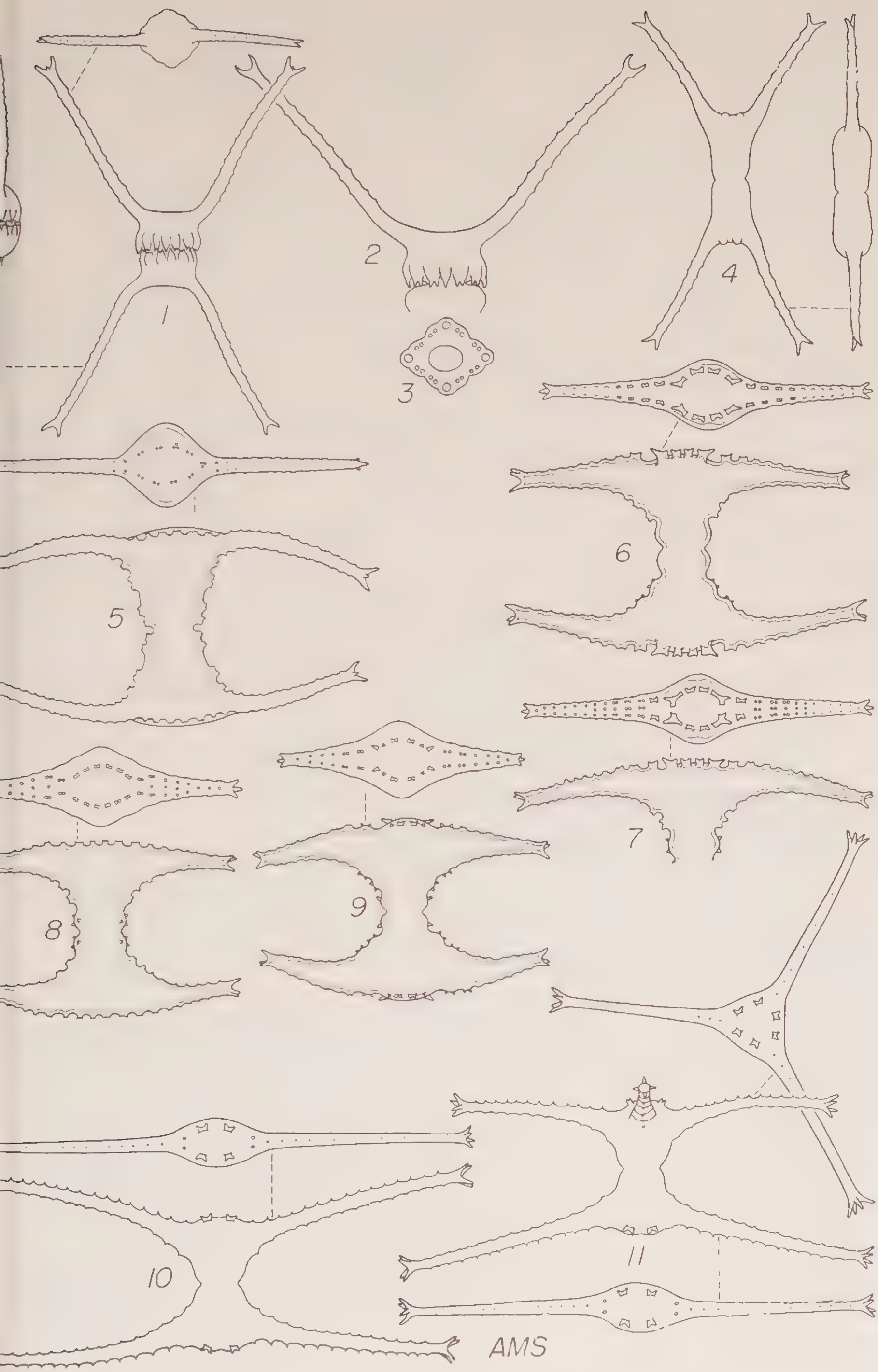


Plate 50

Plate 51.

1. *Staurastrum vaasii* sp. nov. x600.

2. *St. vaasii* Scott & Presc. var. *nudum* var. nov. x640.

3, 4. *St. saltans* Josh. var. *sumatranum* Scott & Presc. x640.

5. *S. saltans* Josh. var. *sumatranum* Scott & Presc. fa. *divergens* Scott & Presc. x640.

6. *St. saltans* var. *kalimantanum* Scott & Presc. x640.

7. *St. saltans* var. *polycharax* Scott & Presc. x640.

8, 9. *St. saltans* var. *javanicum* Scott & Presc. x640.

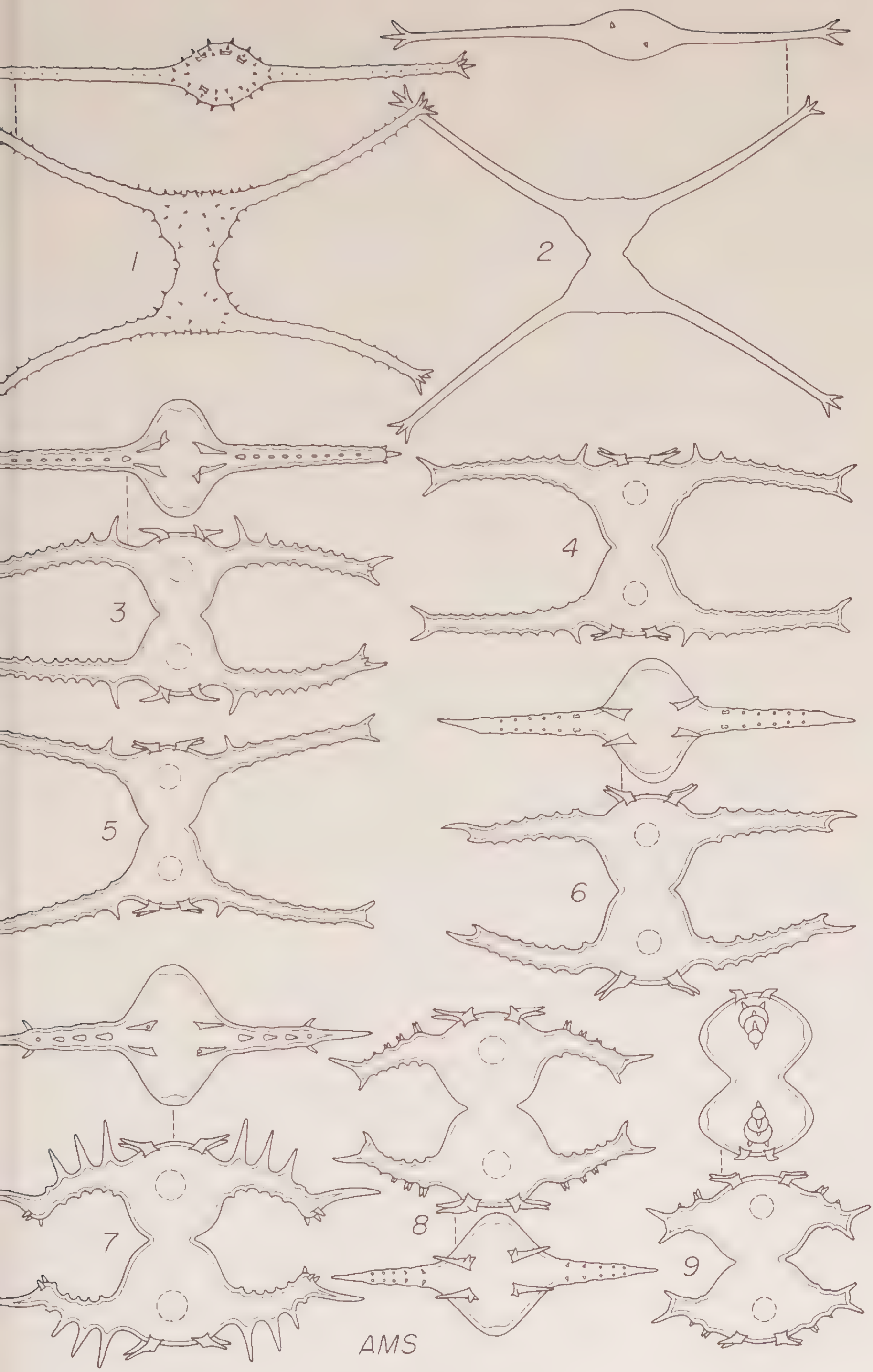


Plate 51

Plate 52.

1. *Staurastrum subsaltans* West & West var. *indonesianum* Scott & Presc. x600.

2. *St. subsaltans* West & West var. *indonesianum* Scott & Presc. fa. *divergens* Scott & Presc. x800.

3. *St. subsuecicum* sp. nov. x800.

4. *St. playfairi* Scott & Presc. nom. nov. x800.

5, 6. *St. acanthocephalum* Skuja x850.

7, 8. *St. smithii* (G. M. Smith) Teiling x850.

9. *St. perundulatum* Grönbl. Fa. x1050.

10. *St. perundulatum* Grönbl. var. *dentatum* var. nov. x850.

11. *St. muticum* (Bréb.) x800.

12. *St. orbiculare* Ralfs var. *depressum* Roy & Biss. x800.

13. *St. pseudopachyrhynchum* Wolle x800.

14. *St. punctulatum* Bréb. x850.

15. *St. coarctatum* Bréb. var. *subcurtum* Nordst. x750.

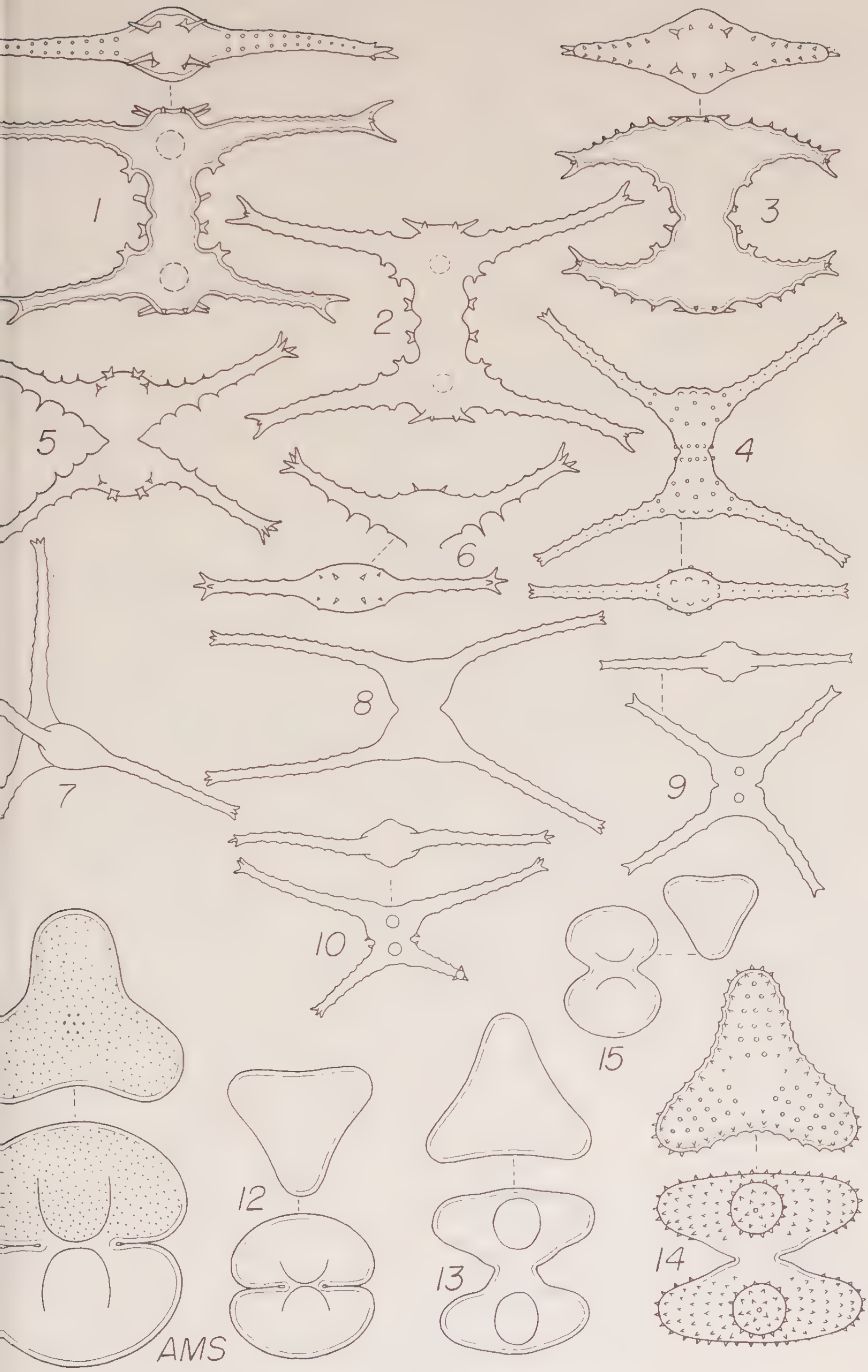


Plate 52

Plate 53.

1, 2. *Staurastrum cryptoëdrum* Skuja x1100.

3, 4. *St. unicorne* Turn. var. *ecorne* West & West fa. *retusum* fa. nov. x800.

5. *St. sublaevispinum* West & West x800.

6. *St. triforcipatum* West & West x850.

7. *St. subgracillimum* West & West var. *tortum* Scott & Grönbl. x800.

8. *St. bigibbum* Skuja x800.

9. *St. curvatum* W. West var. *cruciatum* Krieg. x1000.

10. *St. dejectum* Bréb. x800.

11. *St. diptilum* Nordst. x1100.

12. *St. connatum* (Lund.) Roy & Biss. x800.

13. *St. cuspidatum* Bréb. Fa. x800.

14. *St. cuspidatum* Bréb. fa. *incurvum* Heimerl. x1050.

15. *St. cuspidatum* Bréb. var. *divergens* Nordst. x800.

16. *St. cuspidatum* Bréb. var. *divergens* Nordst. fa. *minus* fa. nov. x800.

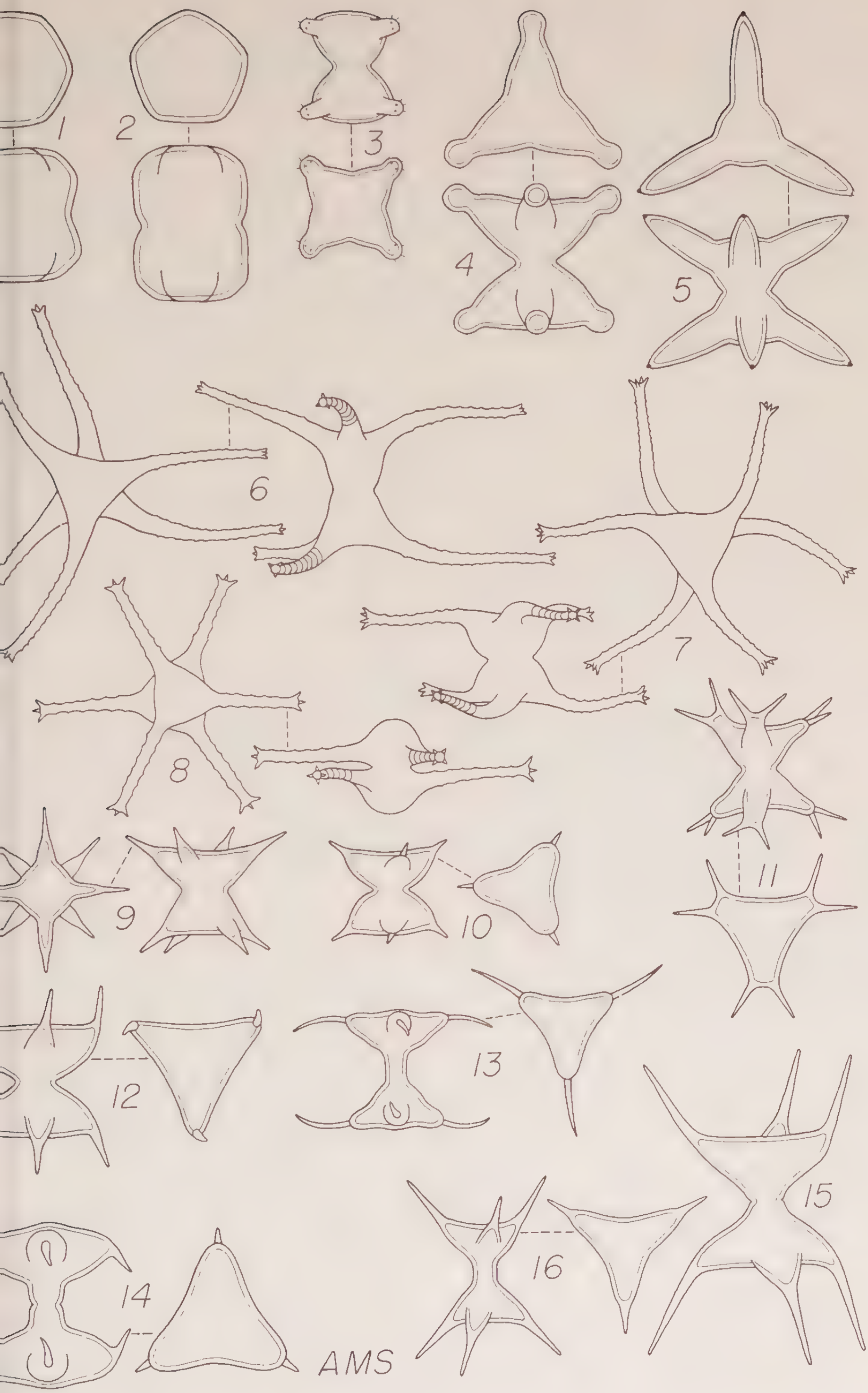


Plate 53

Plate 54.

1-4. *St. corniculatum* Lund. var. *variabile* Nordst. x800.

5. *St. bifidum* Bréb. x800.

6. *St. contectum* Turn. Fa. x800.

7. *St. trissacanthum* sp. nov. x780.

8. *St. trissacanthum* nob. fa. *brachyacanthum* fa. nov. x800.

9. *St. trissacanthum* nob., dichotypical specimen combining the specific form with var. *dissacanthum*. x800.

10. *St. trissacanthum* nob. var. *dissacanthum* var. nov. x800.

11. *St. trissacanthum* nob. var. *dissacanthum* nob. fa. *brevispinum* fa. nov. x850.

12. *St. brachiatum* Ralfs. Fa. x800.

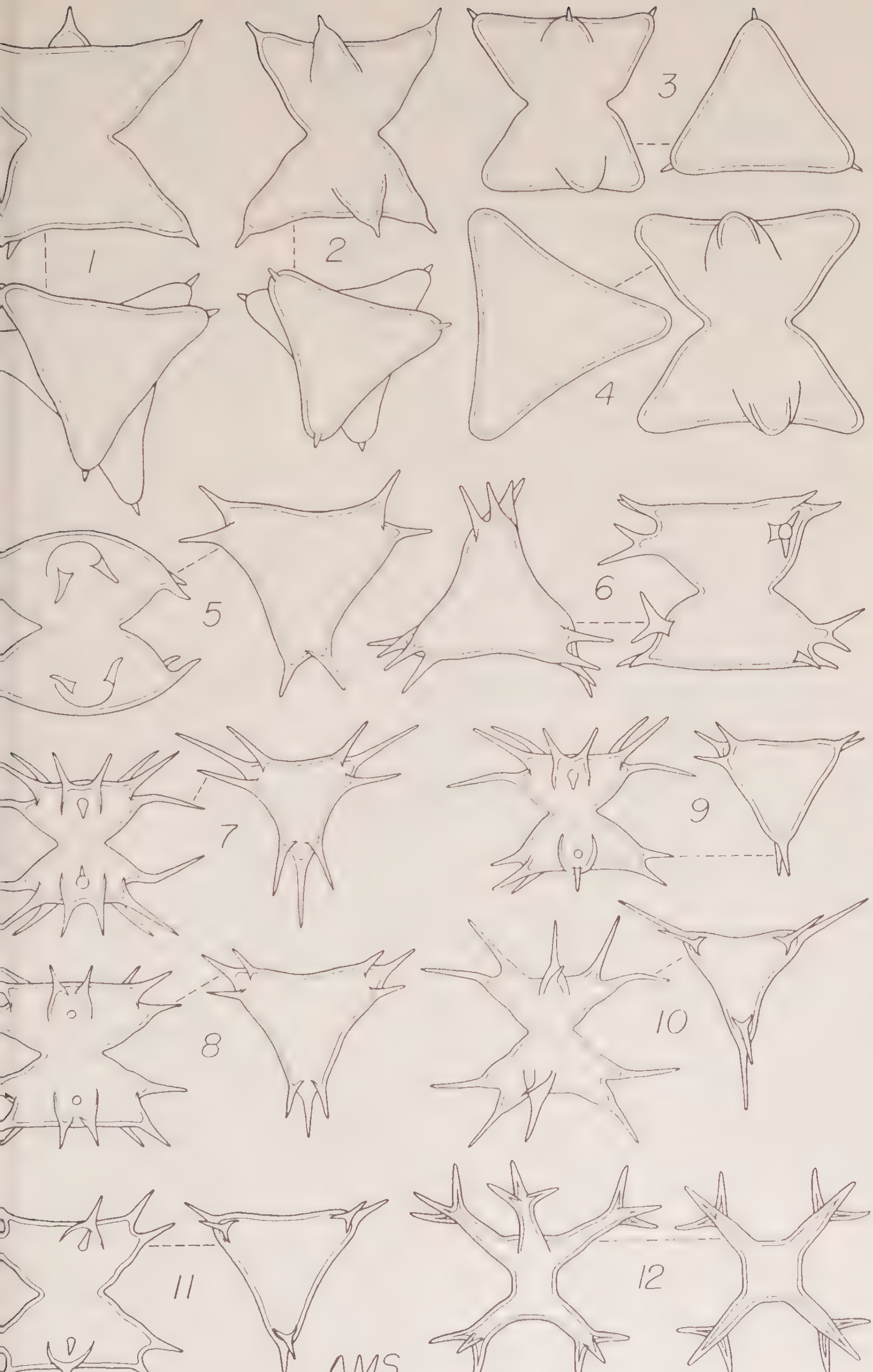


Plate 54

Plate 55.

1, 2. *Staurastrum calyxoides* Wolle var. *orientale* var. nov. x750.

3. *St. megacanthum* Lund. Fa. x775.

4. *St. megacanthum* Lund. var. *kalimantanum* var. nov. x800.

5, 6. *St. megacanthum* Lund. var. *orientale* var. nov. 5 x600, 6 x800.

7, 8. *St. megacanthum* Lund. var. *orientale* nob. fa. *biradiatum* fa. nov. x800.

9. *St. raphidacanthum* sp. nov. x800.

10. *St. brachiatum* Ralfs x800.

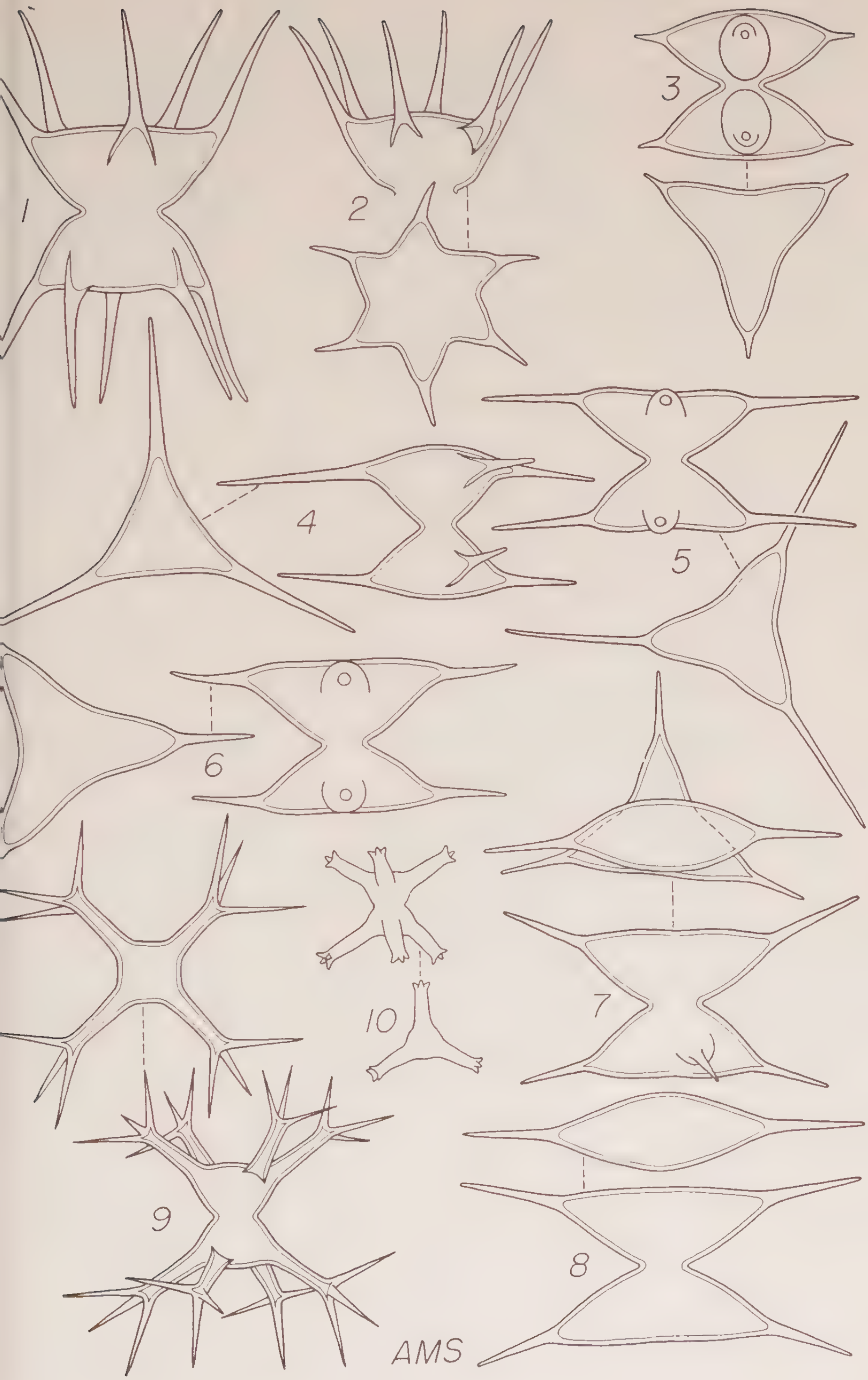


Plate 55

Plate 56.

1. *Staurastrum gladiosum* Turn. x800.

2. *St. setigerum* Lund. x825.

3. *St. horametrum* Roy & Biss. var. *orientale* var. nov. x750.

4. *St. anisacanthum* sp. nov. x1070.

5. *St. anatinoides* Scott & Presc. var. *javanicum* var. nov. x875.

6. *St. cerastes* Lund. var. *coronatum* Krieg. fa. *inflatum* Scott & Presc. x825.

7. *St. cerastes* Lund. var. *pulchrum* Scott & Grönbl. Fa. x800.

8, 9. *St. rhynchoceps* Krieg. var. *curvatum* var. nov. x825.

10. *St. heimerlianum* Lütkem. var. *sumatranum* var. nov. x800.

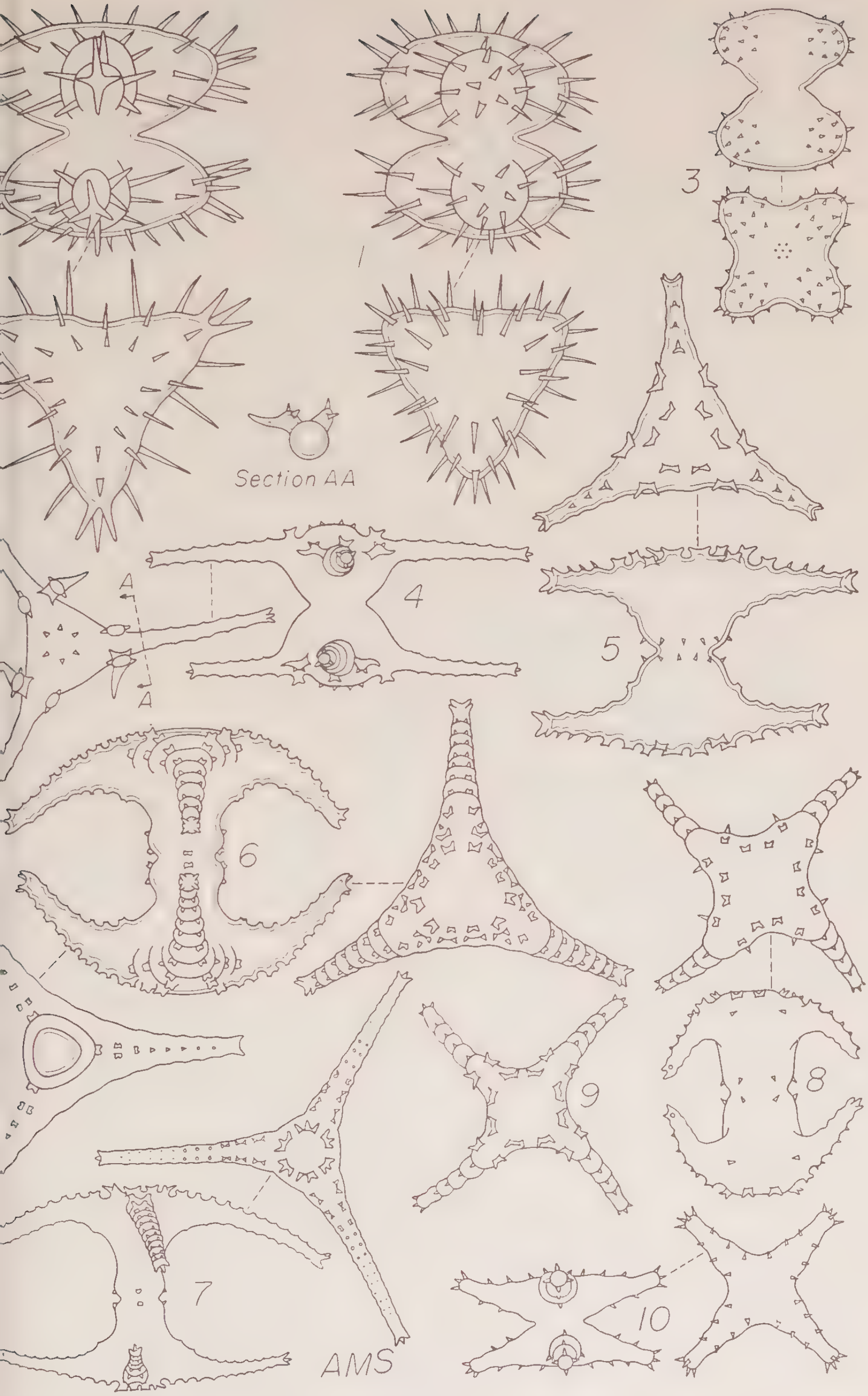


Plate 56

Plate 57.

1-3. *St. cyclacanthum* West & West var. *armigerum* var. nov. x825.

4-6. *St. forficulatum* Lund. var. *aristeron* var. nov. x800.

7-9. *St. senarium* (Ehrbg.) Ralfs. Formae. x800.

10. *St. gracile* Ralfs var. *elongatum* Scott & Presc. x800.

11. *St. gracile* Ralfs fa. *kriegeri* fa. nov. x800.

12. *St. tetracerum* Ralfs x800.

13. *St. tetracerum* Ralfs fa. *trigonum* Lund. x800.

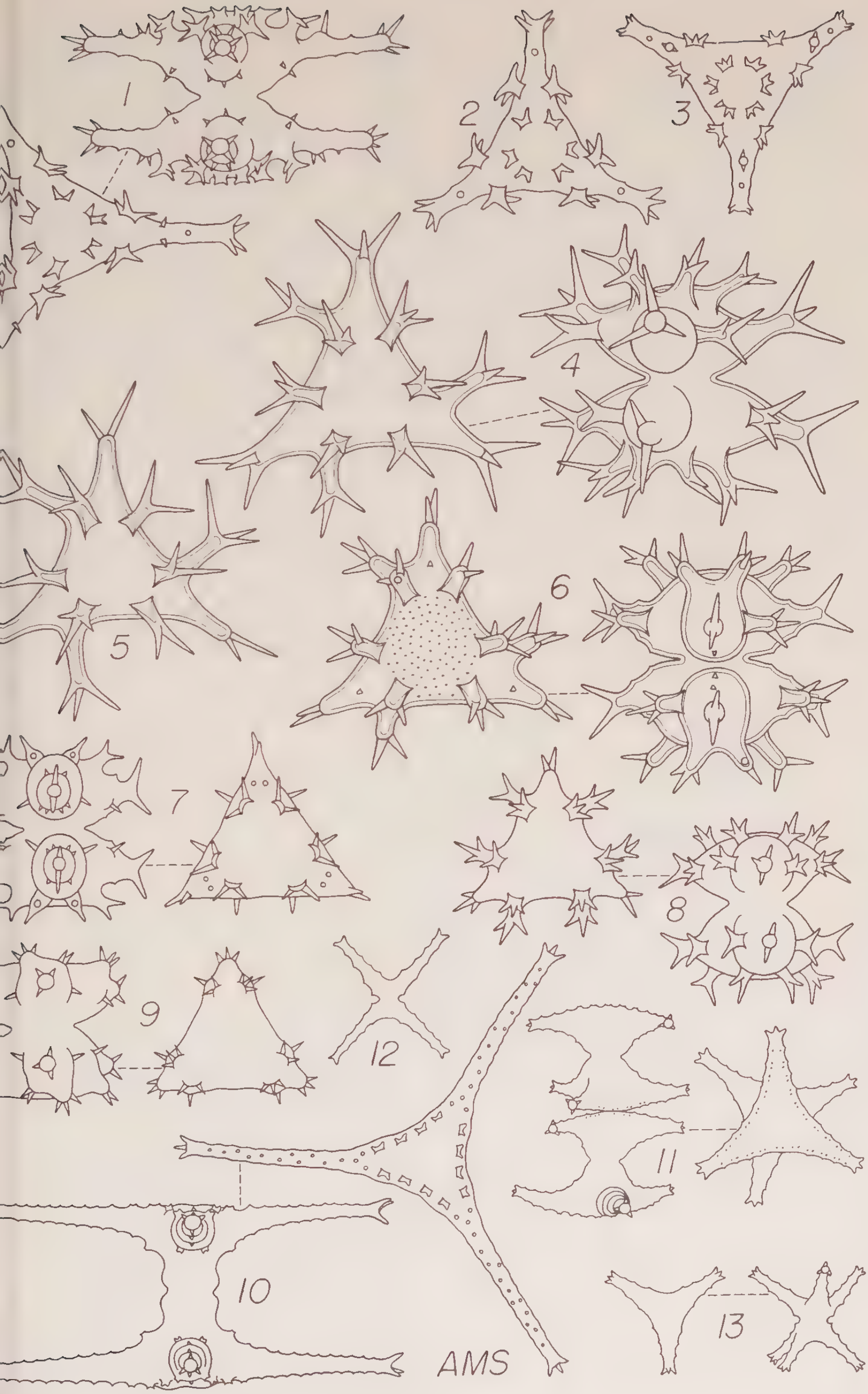


Plate 57

Plate 58.

1, 2. *Staurastrum rosei* Playf. x800.

3. *St. rosei* Playf. var. *stemmatum* var. nov. x800.

4. *St. spiniceps* Krieg. Fa. x800.

5. *St. spiniceps* Krieg. var. *trifidum* var. nov. x800.

6. *St. stauroton* sp. nov. x800.

7. *St. emaciatum* sp. nov. x800.

8. *St. tarantulum* sp. nov. x1070.

9. *St. laeve* Ralfs x750.

10. *St. xanthium* Krieg. x800.

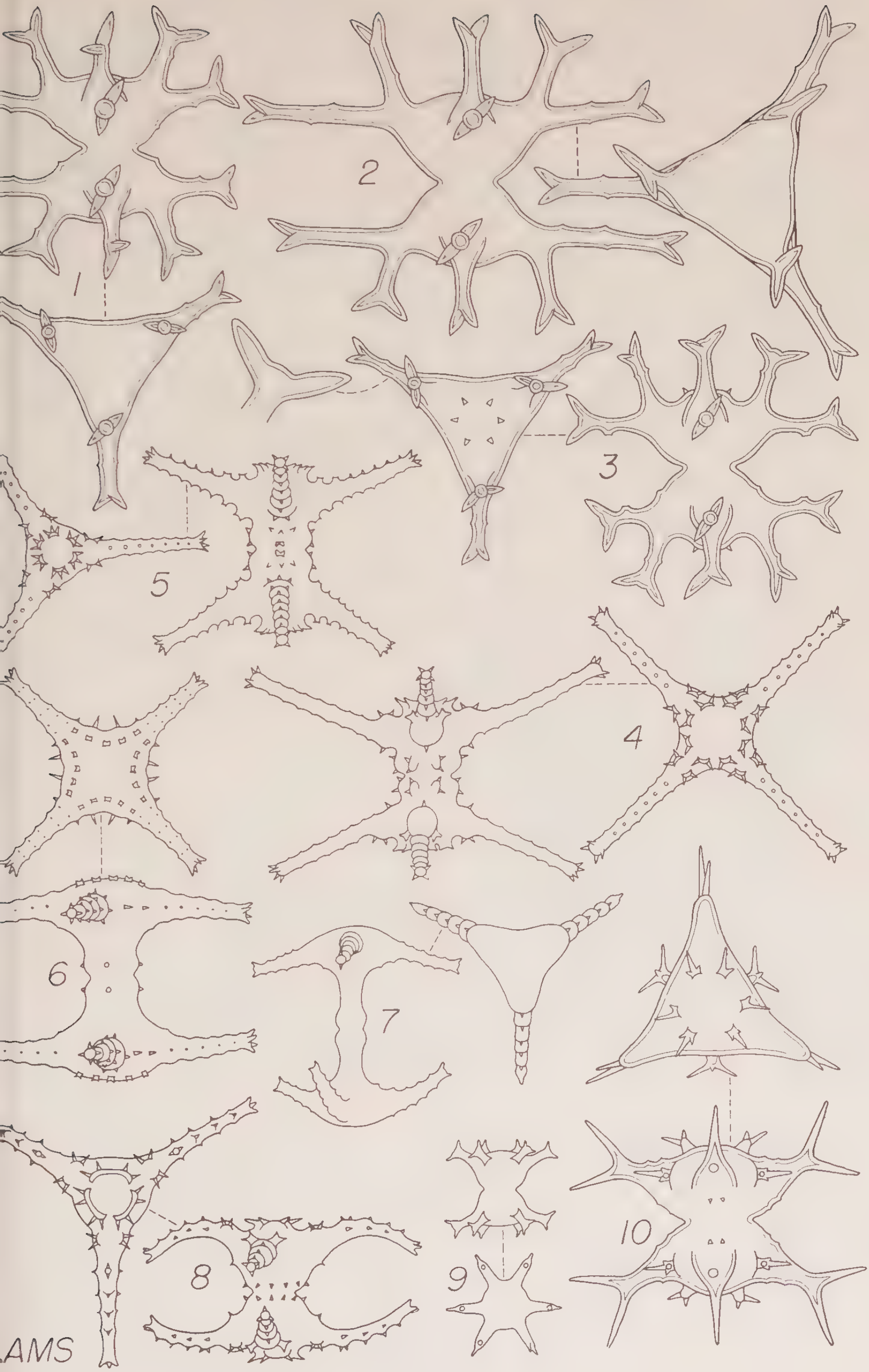


Plate 58

Plate 59.

1. *Staurastrum ceylanicum* West & West x800.
2. *St. zonatum* Börges. var. *ceylanicum* West & West x625.
3. *St. ophiura* Lund. var. *horizontale* Scott & Presc. x850.
4. *St. distentum* Wolle Fa. x800.
5. *St. peristephes* sp. nov. x800.
6. *St. quadricornutum* Roy & Biss. x800.
7. *St. arachne* Ralfs var. *sumatranum* var. nov. x800.
8. *St. dentatum* Krieg. Fa. x1100.
9. *St. vestitum* Ralfs var. *gymnocephalum* var. nov. x850.
10. *St. crenulatum* (Näg.) Delp. Fa. x850.
11. *St. inconspicuum* Nordst. x850.
12. *St. gyratum* West & West var. *dextrum* var. nov. x850.
13. *St. pseudozonatum* Borge var. *minutum* var. nov. x800.
14. *St. polymorphum* Bréb. Fa. x1100.
15. *St. menggalense* sp. nov. x800.
16. *St. margaritaceum* (Ehrbg.) Menegh. var. *gracilius* Scott & Grönbl. x850.

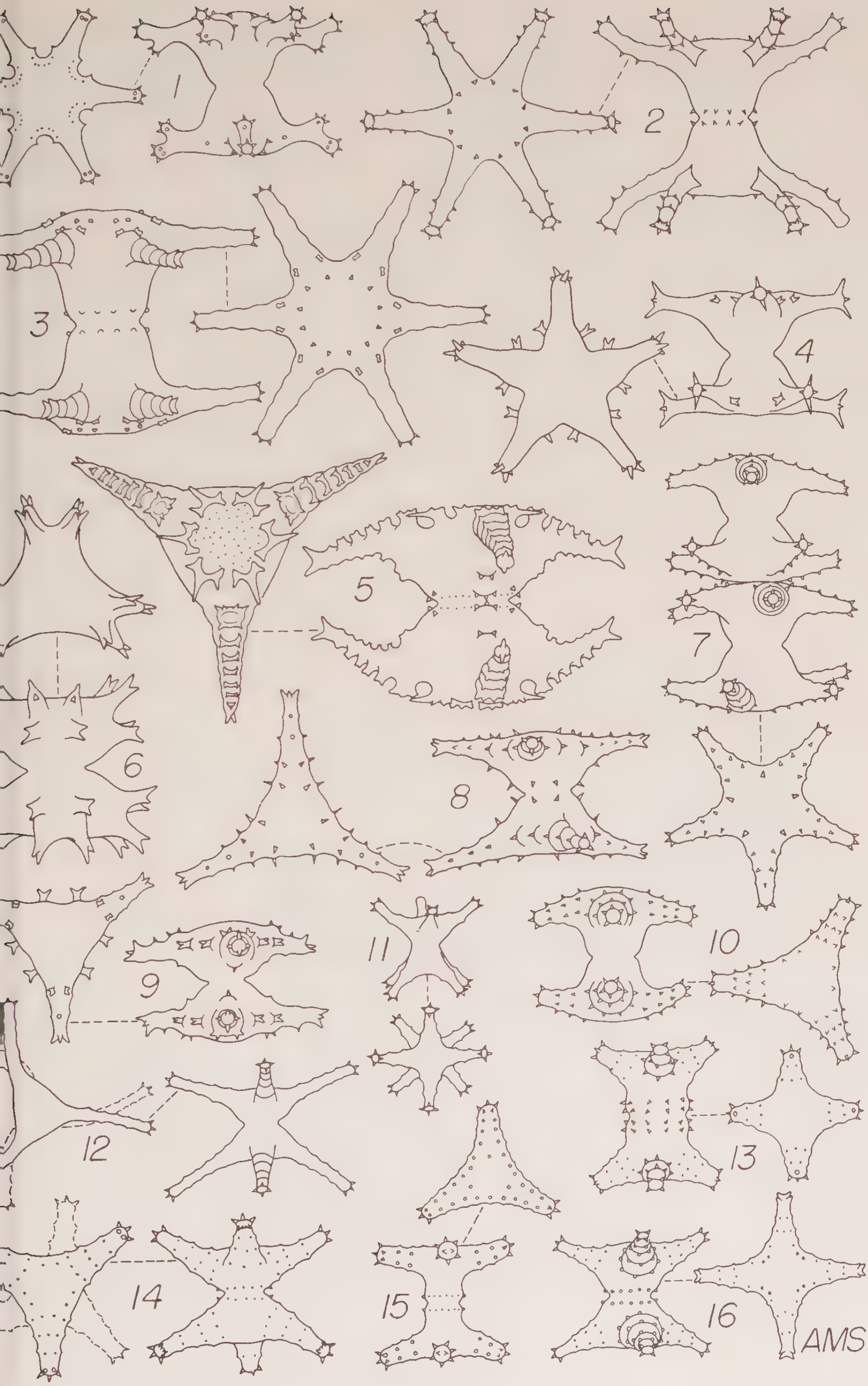


Plate 59

Plate 60.

1. *Staurastrum woltereckii* Behre Fa. x800.

2. *St. gnampton* sp. nov. x825.

3. *St. euprepes* sp. nov. x850.

4. *Euastrum platycerum* Reinsch Fa. x800.

5. *Sphaerozosma granulatum* Roy & Biss. x800.

6-8. *Spondylosium planum* (Wolle) West & West. Three differing forms. x800.

9. *Sp. nitens* (Wall.) Arch. fa. *majus* Turn. x600.

10. *Sp. nitens* (Wall.) Arch. var. *triangulare* Turn. fa. *javanicum* Gutw. x800.

11. *Sp. moniliforme* Lund. x800.

12. *Onychonema laeve* Nordst. var. *constrictum* var. nov. x800.

13. *O. laeve* Nordst. var. *latum* West & West x800.

14. *O. laeve* Nordst. var. *micracanthum* Nordst. x800.

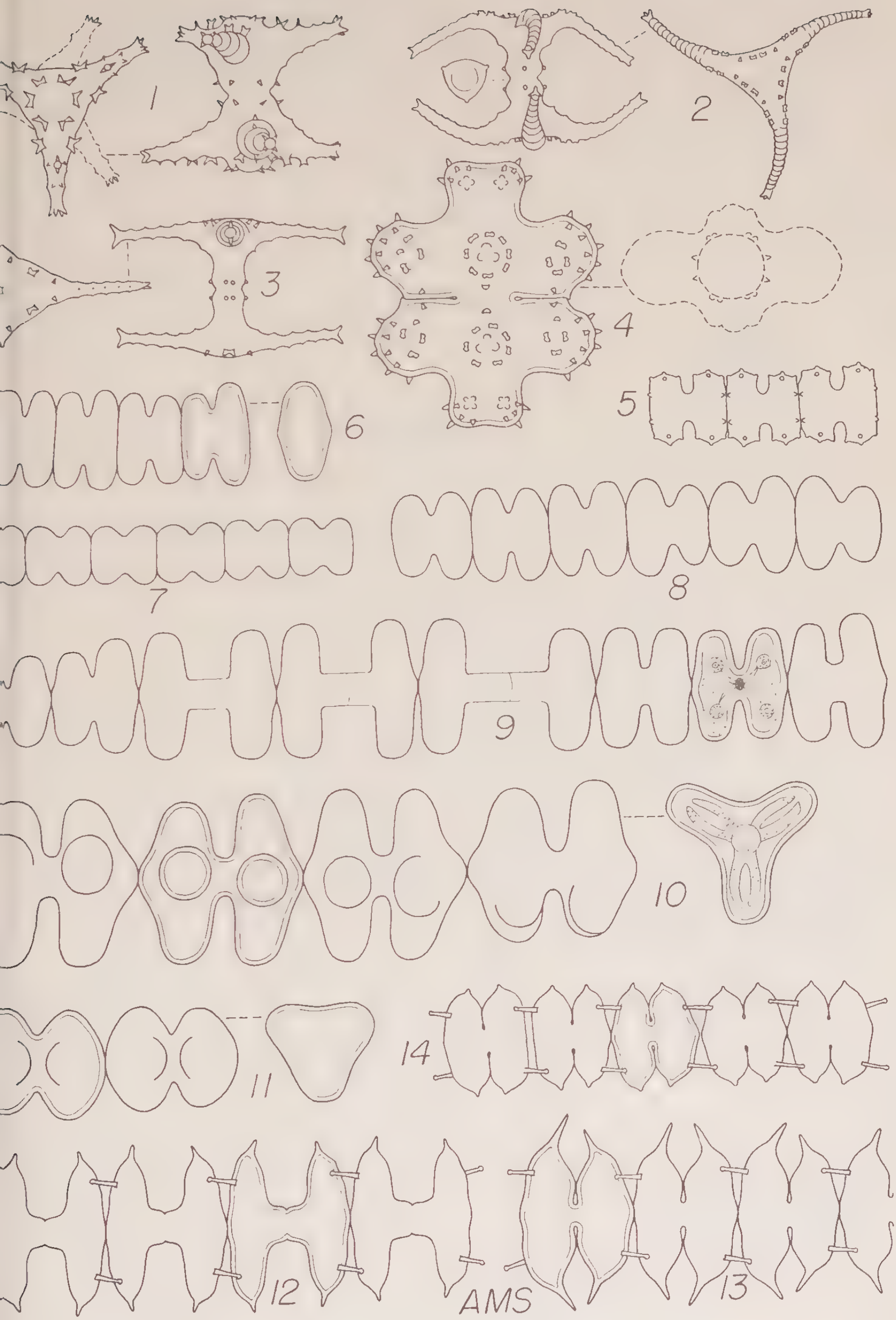


Plate 60

Plate 61.

1. *Onychonema laeve* Nordst. var. *sumatranum* var. nov. x600.

2. *Hyalotheca dissiliens* (Smith) Bréb. var. *hians* Wolle x800.

3. *H. undulata* Nordst. x800.

4. *H. undulata* var. *perundulata* Grönbl. x800.

5, 6. *Groenbladia inflata* Scott & Grönbl. 5 x600, 6 x750.

7. *G. neglecta* (Racib.) Teiling. x600.

8. *G. neglecta* (Racib.) Teiling var. *elongata* Scott & Grönbl. x800.

9, 10. *Phymatodocis nordstedtiana* Wolle 9 x480, 10 x580.

11-15. *Ph. irregularis* Schm. var. *intermedia* Gutw. 11, front view, x480; 12, side view showing ends of longer processes, x600; 13, vertical view, x600; 14, chloroplast x600; 15, vegetative division, x500.

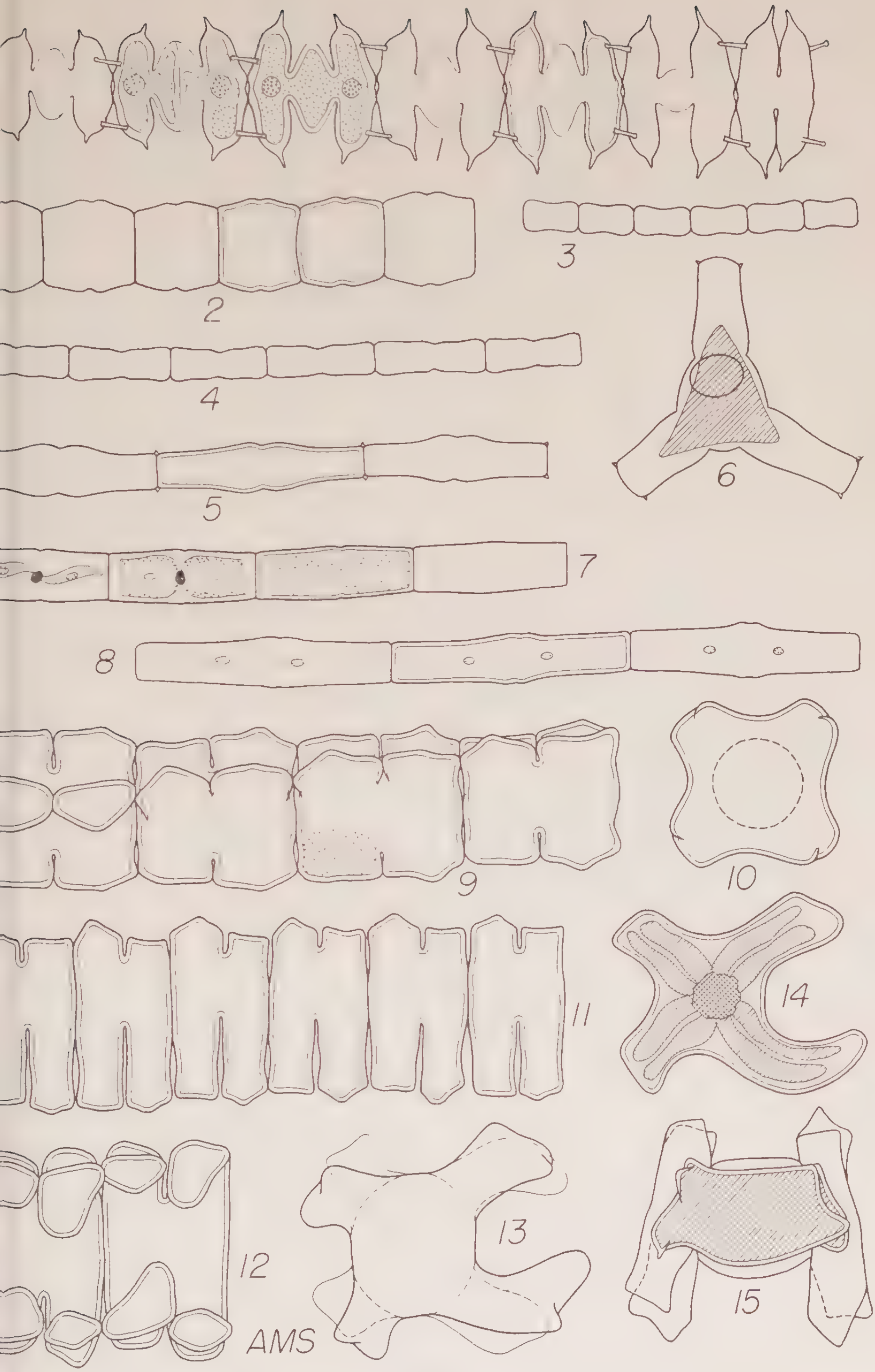


Plate 61

Plate 62.

1. *Bambusina brebissonii* Kütz. x800.

2, 3. *B. brebissonii* Kütz. fa. *constrictum* fa. nov. 2 x600, 3 x800.

4. *B. brebissonii* Kütz. var. *gracilescens* (Nordst.) Wolle x800.

5-7. *Desmidium aptogonum* Bréb. var. *tetragonum* West & West x800.

8, 9. *D. baileyi* (Ralfs) Nordst. fa. *tetragonum* Nordst. x800.

10, 11. *D. baileyi* (Ralfs) Nordst. fa. *longiprocessum* fa. nov. x750.

12, 13. *D. bengalicum* Turn. 12 x600, 13 x800.

14. *D. bengalicum* Turn. fa. *quadratum* fa. nov. x800.

15, 16. *D. grevillei* (Kütz.) De Bary Fa. x600.

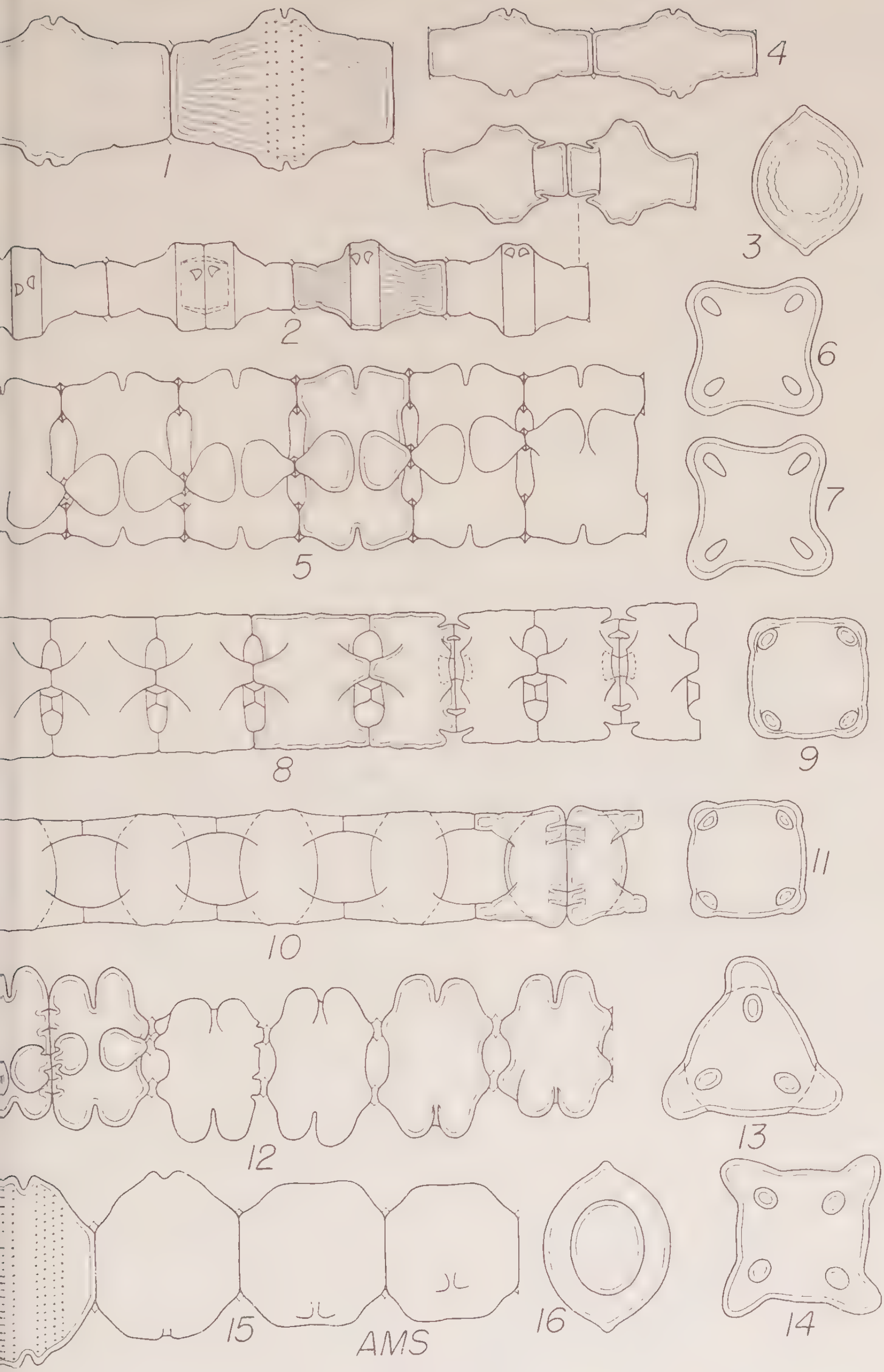


Plate 62

Plate 63.

1-4. *Desmidium graciliceps* (Nordst.) Lagerh., with zygospore. 1-5 x600, 4 x500.

5, 6. *D. quadratum* Nordst. x600.

7. *D. suboccidentale* Scott & Presc. x800.

8. *D. swartzii* Agardh x600.

9. *D. swartzii* Agardh. var. *bicristatum* var. nov. x600.

10-16. *Streptonema trilobatum* Wall. 10, front view x600; 11, rear view showing infolding of apical pads x600; 12-15, various shapes in end view, 12-14 x550, 15 x600; 16, basal view showing shape of isthmus x600.

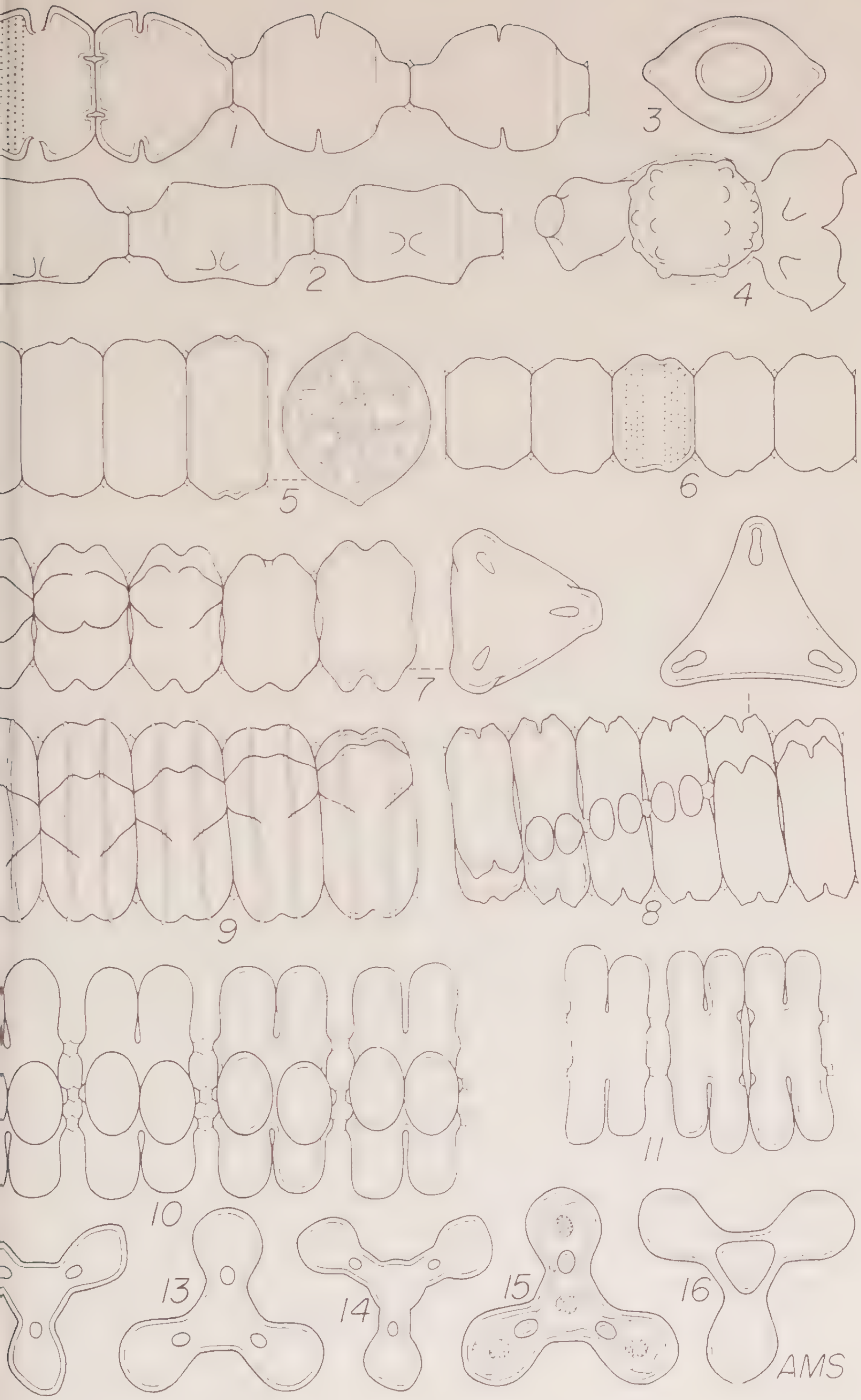


Plate 63

# Ernährungsbiologie einer rhipidoglossen Kiemenschnecke

von

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(mit 3 Fig.)

## I. Einleitung

Bei zahlreichen phytophagen Gastropoden ist mit Hilfe der Direktbeobachtung und der Bißspuranalyse die unterschiedliche Arbeitsweise der einzelnen Radulatypen aufgeklärt und ihre Bedeutung für die Nahrungsaufnahme herausgestellt worden (Ankel 1938, Eigenbrodt 1941, Hubendick 1957, Märkel 1958). Aus Mangel an ausreichenden Angaben über die Nahrung und ihre Verarbeitung im Darmkanal bestehen aber bei wichtigen Schneckengruppen, z. B. bei den rhipidoglossen Kiemenschnecken, noch wesentliche Lücken sowohl über die Beziehungen zwischen Radulafunktion und Ernährungsphysiologie als auch über die Beziehungen zwischen Ernährungsphysiologie und ökologischer Einnischung der Arten. Dieses Beziehungsgefüge konnte am Beispiel der Flußdeckelschnecke *Theodoxus fluviatilis* in Fütterungs- und Zuchtversuchen sowie im Freiland eingehender analysiert werden. *Theodoxus*, ein Prosobranchier mit einer Radula des Rhipidoglossentyps, ist ein ausgeprägter Weidegänger, der in Süß- und Brackgewässern die litorale Steinregion besiedelt und dort die Überzüge einzelliger Algen, meist Diatomeen, frisst (Ulrich & Neumann 1956). Da für die spezifische Radulafunktion und die Nahrungsverarbeitung dieser Schnecke ein steiniger, rauher Freßgrund von entscheidender Wichtigkeit ist, konnten die ökologischen Einnischungsfaktoren Nahrung und Substratbeschaffenheit unter einem gemeinsamen, ernährungsphysiologischen Aspekt untersucht und gedeutet werden.

Die Untersuchungen wurden bei der Ausarbeitung einer Zuchtmethode für *Theodoxus* am Zoologischen Institut Göttingen im Rahmen einer Arbeit über das Farbmuster der *Theodoxus*-Schale (NEUMANN 1959) begonnen. Sie werden ergänzt durch eine unveröffentlichte Teiluntersuchung von F. JANTZEN, die in einer Staatsexamensarbeit niedergelegt wurde. Herrn JANTZEN bin ich für die Mitteilung seiner Ergebnisse zu besonderem Dank verpflichtet.

## II. Material und Methoden

Die Arbeitsweise der Radula von *Theodoxus fluviatilis* (L.) wurde erstens direkt beobachtet und zweitens indirekt aus den beim Abweiden des Freßgrundes beobachteten Leistungen sowie den auf Fettplatten (Glasscheiben mit Palminfilm) sich abzeichnenden Bißspuren erschlossen. Die Nahrungsaufnahme und die Nahrungsverarbeitung konnten anhand der mikroskopischen Untersuchung des Magen-, Darm- und Kotballeninhalts verfolgt werden. Die Freilandbefunde wurden an Flußdeckelschnecken aus der Werra (Standort Hedemünden), dem Nord-Ostsee-Kanal (Standort Rendsburg), dem Flachlandsbach Kossau (Standort Rantzau Holstein) und dem Großen Plöner See (Holstein) gewonnen. Im Laboratorium wurden einzellige und fädige Algen aus folgenden Klassen und Ordnungen als Futter angeboten: Cyanophyceae (Hormogonales), Flagellatae (Volvocales), Diatomeae (Pennales), Chlorophyceae (Chlorococcales, Cladophorales), Conjugatae (Desmidiales) und Rhodophyceae. Auf eine Artbestimmung der Algen konnte verzichtet werden, da die Gattungs- oder Ordnungszugehörigkeit ausreichte, um die ernährungsbiologische Bedeutung der einzelnen Algengruppen richtig einzuschätzen. In Beispielen mit vorliegendem Artnamen stammten die Algen aus der „Sammlung von Algenkulturen" des Pflanzenphysiologischen Instituts Göttingen[1]). Sie wurden z. T. für Massenkulturen bei den Dauerzuchten von *Theodoxus fluviatilis* verwendet (s. S. 140).

## III. Bau und Arbeitsweise der Radula

Die unterschiedliche Bezahnung der Prosobranchierradula, die zur Unterteilung in vier Hauptgruppen (Rhipidoglossa, Dokoglossa, Taenioglossa, Stenoglossa) führte, bedingt eine verschiedene Arbeitsweise und steht in enger Beziehung zur Nahrungsaufnahme (ANKEL 1938). Die Flußdeckelschnecke *Theodoxus fluviatilis* gehört zu den Rhipidoglossa, der Gruppe mit „Randbürstenradula" (ANKEL). Die typische Rhipidoglossenradula weist innerhalb einer Zahnquerreihe zwei morphologisch und funktionell verschiedene Zahnelemente auf; erstens den unpaaren Mittelzahn sowie die seitlich von diesem in geringer Zahl stehenden Zwischenzähne und zweitens die beiderseits anschließenden, sehr zahlreich in einem fächerartigen Wall stehenden Randzähne (bei *Theodoxus* ca. je

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[1]) Herrn Dr. W. KOCH, Göttingen, danke ich für die freundliche Überlassung von zahlreichen Reinkulturen.

40—50 Stück). Bei *Theodoxus fluviatilis* (Abb. 1) fällt von den Zwischenzähnen besonders der 4. durch seine Grösse, seine schaufelartige Form mit den an der Zahnkrone stehenden Dornen (Dentikeln) und seine breite, der Basalmembran aufliegende Basalplatte auf (vgl. auch Abb. 3, S. 144). Der Mittelzahn und die restlichen Zwischenzähne (1.—3.) sind schwach ausgebildet und erheben sich nur geringfügig über die Basalmembran. Die Arbeitsweise der Rhipidoglossenradula wurde am Beispiel der Trochide *Gibbula cineraria* L. von ANKEL (1938) und EIGENBRODT (1941) in den wesentlichsten Punkten aufgeklärt und am Beispiel der Neritine *Theodoxus fluviatilis* von JANTZEN ergänzt. Im Verlauf eines Freßaktes werden die elastisch biegsame Radula und der ihr anliegende Radulaknorpel aus dem Mund herausgeschoben und dem Freßgrund angedrückt.

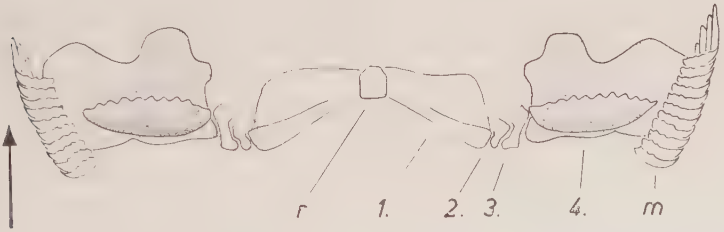
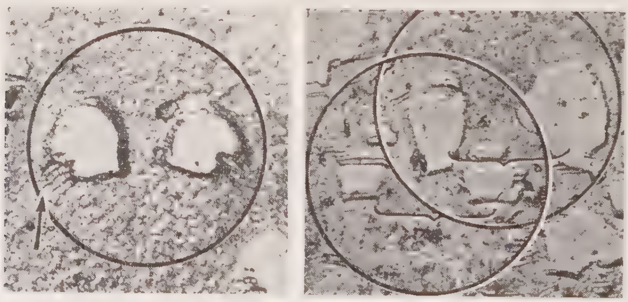



Abb. 1 *Theodoxus fluviatilis*, eine Querreihe der Radula. r: Mittel-(Rachis-) zahn; 1., 2., 3., 4.: 1. — 4. Zwischen- (Lateral-) zahn; m: Rand-(Marginal-) zähne, nur z.T. dargestellt und perspektivisch verkürzt. Vergr. 150 x. Der Pfeil zeigt die Arbeitsrichtung der Radula an.

Die hierauf schlundwärts gezogene Radula gleitet über den Radulaknorpel, der sich bei *Theodoxus* gleichzeitig entgegengesetzt von vorn nach hinten (bezogen auf die Körperlängsachse) über den Untergrund verlagert (JANTZEN)[1]). Am Vorderrand des Radulaknorpels, der sog. Knickkante, ist die Radula in ihrer ganzen Breite auf dem Untergrund ausgebreitet. Nach Passieren der Knickkante klappen die fächerartigen Randzähne von den Seiten über dem Mittelteil der Radula zusammen. An den Bißspuren von *Gibbula* konnte ANKEL die Arbeitsweise der Randzähne verfolgen. Ihre Spuren „zeigen nämlich die unverkennbare Wirkung bürstenartig federnder Gebilde, die im Bogen gegen die Mitte zugeführt werden, sich dort treffen, ja vielleicht sogar etwas aneinander vorbeigehen. Der Feinheit der Spur nach zu urteilen, können das nur die Fächer

[1]) Die gleiche Bewegungsrichtung des Radulaknorpels wies erstmals EIGENBRODT (1941) bei *Gibbula* und *Viviparus* nach. Pulmonaten (MÄRKEL 1958) und zahlreiche Prosobranchier (z. B. die taenioglosse *Littorina* und die rhipidoglosse *Emarginula*) zeigen dagegen eine von hinten nach vorn verlaufende Bewegung des Radulaknorpels (vgl. Anm. S. 145).

der Randzähne sein, die wie Bürsten den – vielleicht von den Zwischenzähnen vorbereiteten – Freßgrund bearbeiten, mit dem Ergebnis einer Säuberung, die so gründlich ist, wie bei keinem der bisher bekannten Weidegänger" (ANKEL 1938, S. 244—245). Auch EIGENBRODT fand bei ihren späteren Untersuchungen in den Bißspuren von *Gibbula* keine Abdrücke des Mittelzahnes und der Zwischenzähne und konnte daher nur vermuten, daß sie den Freßgrund abkratzen, während die bürstenartigen Randzähne das Gut zusammenfegen. Die Untersuchung der Bißspur von *Theodoxus* gab dagegen eine klare Antwort über die Funktion der Zwischenzähne. Während auf algenbewachsenen Glasplatten keine Zahnspuren zurückbleiben – der Algenbelag wird fast quantitativ aufgenommen –, erhielt JANTZEN auf Fettplatten bei jedem Biß zwei markante, benachbarte Löcher im Freßgrund (Abb. 2). Der Durchmesser und Abstand der Löcher entsprach bei verschieden großen Tieren der Größe und dem Abstand der 4. Zwischenzähne auf der Radula (Abb. 2b). Die kräftigen Löcher sind demnach eindeutig auf die Tätigkeit der beiden Reihen der 4. Zwischenzähne zurückzuführen, die im Ablauf eines Bisses über den Freßgrund gezogen werden. Die Randbürsten hinterlassen in dem Palmin nur selten schwache Abdrücke, die wie bei *Gibbula* auf die Mitte der Radula gerichtet sind. Ihr Wirkungsbereich reicht jedoch im Gegensatz zu *Gibbula* nicht bis zur Mittellinie der Radula, sondern er ist auf den Umkreis der 4. Zwischenzähne beschränkt, wie durch das Fehlen jeglicher Ab-



a b

Abb. 2. Bißspuren von *Theodoxus fluviatilis* auf einer Fettplatte. (n. Aufnahmen von JANTZEN). a: Einzelbiss in einem grobscholligen, dicken Palminfilm, Vergr. 85x; b: zwei nebeneinanderliegende Bisse in einem feinscholligen, dünnen Palminfilm, Vergr. 75x. Das typische Abstandsverhältnis zwischen den beiden Reihen der 4. Zwischenzähne (vgl. Abb. 1) gibt Bild b wieder. Es ist in Bild a nicht ablesbar; hier ist das Fett nicht allein im Bereich der 4. Zwischenzähne abgetragen, sondern es ist auch aus dem Zwischengebiet — vermutlich aufgrund einer ungünstigeren Beschaffenheit des Palminfilms — mitgerissen worden.

drücke im Gebiet zwischen den 4. Zwischenzähnen belegt wird (Abb. 2 a u. b). Da die 4. Zwischenzähne jeweils das Fett bis zum Glasgrund entfernten, sind die Randbürstenspuren nur an den Lochrändern zu erkennen (Abb. 2, s. Pfeil). Sie dürften auf den Nahrungsgrund nur einen wesentlich schwächeren Druck ausüben und die durch die 4. Zwischenzähne gelockerten Nahrungspartikel tatsächlich einkehren (vgl. S. 145). Mittelzahn und 1.—3. Zwischenzahn hinterlassen keinerlei Spuren; sie sind bei *Theodoxus* funktionell indifferent und spielen bei der Nahrungsaufnahme keine Rolle.

Anhand der Beobachtung des Freßaktes und der Analyse der Bißspur allein kann die Arbeitsweise und die Leistungsfähigkeit einer Radula noch nicht erfaßt werden. Erst im Zusammenhang mit der Beobachtung der Nahrungsaufnahme kann die Radulafunktion einer Schneckenart vollständig geklärt werden. Die Schnecken mit Rhipidoglossenradula sind Weidegänger, die Algenüberzüge im typischen Pendelfraß von einem festen Substrat abschaben. *Theodoxus* bewältigt beim Weidegang allein ein bis wenigzellige Algenformen, die dem Subtrat locker anhaften. Ein Abkratzen von festgewachsenen Algenkrusten, ein stückweises Abbeißen von fädigen Grünalgen (z. B. *Cladophora*, s. S. 141) ist im allgemeinen nicht möglich. Auch die Gewebe höherer Pflanzen werden beim Weidegang auf Blattflächen nicht verletzt. Einzelheiten hierzu bringen die beiden folgenden Kapitel. Da *Theodoxus* Kieferbildungen fehlen, ist auch ein Abreißen größerer Gewebestücke, etwa in der Art, wie es von Märkel (1958) bei dem Pulmonaten *Arion* festgestellt wurde, ausgeschlossen. Eine Ernährungsweise als Planktonsammler durch Strudeln liegt bei *Theodoxus* nicht vor; mit dem Atemstrom eingestrudelte Partikel werden auf bestimmten Bahnen sofort wieder aus der Mantelhöhle befördert (Schäfer 1953).

## IV. Aufnahme und Verdaubarkeit der Nahrung

In der faunistischen und ökologischen Molluskenliteratur finden sich nur gelegentlich kurze Hinweise auf die Nahrung von *Theodoxus*. Eine Zusammenstellung der Literaturstellen gibt Frömming (1956). Die Art der pflanzlichen Nahrung wird meist unzulänglich mit „Algen" beschrieben; Jaeckel (1952) nennt „Kleinalgen, Diatomeen, Peridineen, Aufwuchs der Seegrasblätter und des Schlammes", Schäfer (1953) schreibt „Algenrasen (Grünalgen, Diatomeen)". Es wird auch angegeben, daß *Theodoxus* tierisches Eiweiß als Nahrung wählt (Borcherding 1888; Schermer 1937; zit. Frömming 1956) und „in erster Linie Fleischfresser" ist (Schermer 1937). Differenziertere Nahrungsbestimmungen fehlen. Weiterhin ist stets die Verdaulichkeit der aufgenommenen Nahrung unberücksichtigt geblieben. Wie im einzelnen gezeigt wird, ist gerade dieser letzte Gesichtspunkt für ein Verständnis der Ernährungsbiologie sowie der ökologischen Einnischung von *Theodoxus* besonders wesentlich, da nur wenige Algensorten für die Ernährung verwertet

werden können. Im folgenden werden zunächst die Freilandbeobachtungen aufgeführt. Anschließend werden die im Laboratorium an verschiedenen Algengruppen gewonnenen Ergebnisse in systematischer Reihenfolge genannt. Da die ernährungsbiologischen Untersuchungen auf eine Zuchtmethode für *Theodoxus fluviatilis* ausgerichtet waren und da sich weiterhin nur wenige Algen für ertragreiche Kulturen eigneten, wurden im Fütterungsversuch auch Algensorten (Cyanophyceae, Volvocales, Rhodophyceae) geprüft, die den Tieren normalerweise im Freiland nicht zur Verfügung stehen. Angaben über die Massenvermehrung der für die *Theodoxus*-Züchtung geeigneten Futteralgen finden sich in den betreffenden Abschnitten.

**Freilandbeobachtungen.**

Die Magen- und die Kotballenuntersuchung ergaben an allen bisher untersuchten Standorten (Werra, Nord-Ostsee-Kanal, Gr. Plöner See, Kossau), an denen die Schnecken im Bereich der litoralen Steinregion den Algenaufwuchs abweiden, ein einheitliches Bild. Die aufgenommene Nahrung bestand zu 80—100 % aus Diatomeen. Dabei fanden sich neben leeren und zerbrochenen Kieselschalen auch unverletzte Zellen mit vermutlich völlig unversehrtem Zellinhalt, und zwar sowohl im Magen als auch im Darm und in den Kotballen. Nur in wenigen Fällen wurden auch vereinzelte Grünalgen (Chlorophyceae) gefunden, und zwar sowohl einzellige Chlorococcalen als auch Endstücke von jungen *Cladophora*-Fäden[1]). Die Chlorophyceen werden jedoch – soweit bei den fädigen Formen keine Zellen beim Abreißen verletzt wurden – nicht verdaut. Neben den aufgenommenen Algen findet sich weiterhin stets noch ein gewisser Anteil mineralischer Partikel (Kalk- oder Quarzkörner je nach Substrat); ihre mögliche Bedeutung für die Nahrungsverarbeitung wird in Abschnitt V (S. 142) diskutiert.

**Laboratoriumsbeobachtungen.**

An algenbewachsenen Aquarien-Glaswänden kann die Aufnahme von verschiedenen Aufwuchsalgen unmittelbar gut verfolgt werden. Werden hierbei verschiedene Algensorten getrennt angeboten, so kann anschließend durch Präparation des Magens und des Darmes die Nahrungsverarbeitung geprüft werden. Soweit die Aufnahme nicht unmittelbar verfolgt werden sollte, wurden die einzelnen Algensorten in Milchsatten, die sich als Zuchtgefäße für *Theodoxus* bewährten, angeboten.

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[1]) Wie weiter unten beschrieben wird, ist *Theodoxus* nicht in der Lage, mit der Radula von längeren und ausdifferenzierten *Cladophora*-Fäden Stücke abzureißen. In diesem speziellen Fall hatten die Schnecken junge und dichte *Cladophora*-Aufwuchsrasen, bei denen die einzelnen kurzen Fadenstücke erst etwa 5 Zellen zählten, beweidet. Es darf angenommen werden, daß die jungen Cladophoraspitzen noch weiche Zellmembranen besitzen und der Radula nur geringen Widerstand entgegensetzen.

Cyanophyceae. Fädige Formen aus der Gruppe der Hormogonales (Oscillatorien) treten häufig in Aquarien in reichlicher Menge auf und bilden flächige Überzüge auf Steinen, Glasscheiben und Wasserpflanzen. Sie breiten sich infolge ihrer gleitenden Kriechbewegungen auf dem Subtrat rasch aus und lassen sich meist leicht kultivieren. Solange diese Überzüge sehr dünn sind, vermag *Theodoxus* von Einzelfäden Stücke abzuzupfen und zu fressen. Die aufgenommenen Cyanophyceen werden gut verdaut. Die Zellwände sowie die extrazellularen Scheiden werden im Magen völlig aufgelöst, so daß blaugrüne Zellbestandteile im Darm nicht mehr nachweisbar sind.

Obwohl *Theodoxus* bei reiner Cyanophyceenernährung über mehrere Wochen gehalten werden konnte, ohne daß eine sichtbare Schwächung der Tiere auftrat, stellen die blaugrünen Algen kein ideales Futter für die Dauerzucht dar. Erstens können sich die Jungtiere nur von sehr feinfädigen Arten ernähren. Zweitens läßt sich ein Überhandnehmen der raschwüchsigen Algen nur mit Mühe vermeiden. Werden die Cyanophyceenrasen aber erst sehr dicht und beginnen die Fäden auf ihrer Oberfläche miteinander zu verschleimen, so ist auch ausgewachsenen Tieren deren Aufnahme unmöglich. Es kann dann weiterhin eintreten, daß die schwerfälligen Flußdeckelschnecken besonders während ihrer täglichen Ruhephase von den kriechenden Fäden allmählich überwuchert und unter einem dicht schließenden Rasen festgehalten werden und schließlich ersticken. Im Freiland spielen die Cyanophyceen als Nahrung an den von *Theodoxus* besiedelten Standorten offenbar keine Rolle.

Flagellatae (Volvocales). Bei Nährstoffmangel, Überbesiedlung oder bei Übertragung in ein Medium mit höherem Salzgehalt verlieren die grünen Flagellaten der Gattung *Chlamydomonas* (Ordnung Volvocales) ihre Geißeln und gehen in einen unbeweglichen Ruhezustand über, in dem sie zusätzlich durch eine Gallertbildung an den Zellmembranen häufig miteinander verkleben und geschlossene Algenrasen bilden. Derartige Rasen können im Labor leicht erziehlt werden; sie werden von *Theodoxus* quantitativ abgeweidet. Im Gegensatz zu den unbegeißelten Chlorococcalen (s. Chlorophyceae, S. 141) werden die Chlamydomonaden (die in den Fütterungsversuchen verwendete Art war *Chl. eugametos*) leicht und gut verdaut. Bei Verfütterung auf glatten Glaswänden ohne Zusatz mineralischer Partikel sind im Darm und Kot allein die unverletzt und unverdaut zurückgebliebenen Zellmembranen gelegentlich wiederzufinden.

Bei ausschließlicher Verfütterung von *Chlamydomonas* ist eine Dauerzucht von *Theodoxus* möglich (Neumann 1959). Die Schnek-

ken wurden mehrfach vom frischgeschlüpften Jungtier bis zur ausgewachsenen und sich fortpflanzenden Schnecke aufgezogen, ohne daß eine Verminderung der Vitalität und der Fortpflanzungsrate auftrat. Trotz der geeigneten Futtereigenschaften der Chlamydomonaden empfiehlt es sich, auf sie nur zurückzugreifen, wenn Diatomeen nicht in genügender Menge zur Verfügung stehen, da die bei ihrer Verfütterung in den undurchlüfteten Zuchtgefäßen leicht einsetzende Sauerstoffzehrung einen häufigen Mediumwechsel (etwa alle 8 Tage) notwendig macht.

Als Nährlösung für die Massenkultur von *Chlamydomonas eugametos* bewährte sich eine verdünnte KNOPsche Nährlösung (1 Teil KNOP — 3 Teile Aqua dest. und 5 % Erddekokt). Das Ausgangsmaterial bildeten auf Agarnährböden gezogene Reinkulturen. Die Massenvermehrung erfolgte in drei Stufen: 1. Vorvermehrung als Reinkultur in Erlenmeyer-Kolben (250 $cm^3$), 2. Vorvermehrung als Reinkultur in durchlüfteten 2 Liter-Stehkolben und 3. Kultur in durchlüfteten 5 Liter-Glasbecken mit unsterilisierten Nährlösungen. Auf der dritten Stufe erfolgt die abschließende Vermehrung nur, wenn begeißelte Stadien sehr reichlich übergeimpft werden. Nach Abschluß der Vermehrung setzen sich die Chlamydomonaden allseitig an den Glaswänden ab. Hier können sie nach Dekantieren der verbrauchten Nährlösung leicht als dickes Futterkonzentrat abgeerntet werden. Die Entwicklungsgeschwindigkeit der Algen hängt von den jahreszeitlich unterschiedlichen Licht- und Temperaturverhältnissen ab, soweit keine licht- und thermokonstanten Räume zur Verfügung stehen. Nach Übertragung des Futterkonzentrates in die *Theodoxus*-Zuchtmedien mit Salzgehalten zwischen 1,5 und 15 ‰ S werden die Flagellaten nicht wieder beweglich. Ein Futterüberangebot ist zu vermeiden; die angebotene Futterfläche sollte innerhalb von 1 bis 2 Tagen von den Tieren gesäubert werden können.

D i a t o m e a e Die pennaten Diatomeen besitzen unter den Futteralgen von *Theodoxus* die wichtigste Bedeutung. Wie im Freiland werden auch unter Laboratoriumsbedingungen die Diatomeenrasen quantitativ abgeweidet. Die Magenuntersuchungen zeigen jedoch, daß für ihre Verdaulichkeit die Substratbeschaffenheit des Freßgrundes wesentlich ist (s. Kap. V, S. 142). Bei Berücksichtigung der Substratbedingung lassen sich mit Diatomeen die besten Aufzuchtergebnisse erzielen.

In früheren Versuchen wurde aus Mangel an einer für die Massenkultur geeigneten Reinkultur ein Gemisch zahlreicher Arten in von Leitungswasser durchströmten Glasbecken vermehrt. Inzwischen steht die von VON DENFFER (1950) für Massenkulturen verwendete *Nitzschia palea* wieder zur Verfügung (Nährlösung 0,2 g $NaNO_3$, 0,04 g $Na_2HPO_4$, 0,1 g $Na_2SiO_3$, 200 ccm Erddekokt und 800 ccm Aqua dest.). Die Massenvermehrung ist im einzelnen in gleicher Weise wie bei den Chlamydomonaden (s. o.) durchführbar.

C h l o r o p h y c e a e („Grünalgen"). Eine Aufnahme der fädigen Aufwuchsalgen aus der Ordnung der Cladophorales, die an

den von *Theodoxus* besiedelten Standorten häufig vertreten sind, erfolgt nicht. Gelingt es den Tieren zufällig, einen kürzeren Faden mit der Radula zu fassen und ein kleines Stück zu schlucken, so wird dieser kurz darauf wieder ausgespuckt, da es den Tieren nicht möglich ist, den Faden mit Hilfe ihres Freßapparates abzureißen oder gar durchzubeißen. Eine Ausnahme können allein sehr junge *Cladophora*-Rasen gelegentlich bilden (s. S. 137). Auch an der thallösen *Enteromorpha* wird nicht gefressen. Die ein- oder wenigzelligen Arten aus der Gruppe der Chlorococcalen werden dagegen ohne Schwierigkeiten vom Freßgrund aufgenommen. Sämtliche Arten – es wurden die Gattungen *Chlorella*, *Scenedesmus*, *Ankistrodesmus* und *Characium* geprüft – passieren jedoch völlig unverdaut den Magen und Darm. Dieses Ergebnis ist nur in der Richtung zu deuten, daß die starken und bei der Nahrungsaufnahme unverletzt bleibenden Zellmembranen nicht nur selber einem enzymatischen Abbau widerstehen, sondern auch eine Verdauung des Zellinhalts verhindern. Werden die Schnecken über längere Zeit bei dieser Fütterung gehalten, so magern sie bei zunächst uneingeschränkter Nahrungsaufnahme ab und gehen schließlich ein.

Conjugatae. In der gleichen Weise wie die Chlorophyceae verhalten sich die einzelligen Zieralgen (Desmidiales) im Darmtraktus. So wurde die Alge *Closterium* im Weidegang reichlich aufgenommen; die kräftige Zellmembran und der Chloroplast blieben jedoch stets unversehrt.

Rhodophyceae. Versuchsweise wurde *Theodoxus* auch eine einzellige Rotalge (*Porphyridium cruentum*) als Futter angeboten. Es ist die einzige Alge, die nach den ersten Bissen sofort gemieden wird. In einem Versuch, in dem die Tiere auf einen dichten *Porphyridium*-Rasen gesetzt worden waren, blieb der schleimige Algenbrei den Tieren regelrecht im Halse stecken; die Versuchstiere verendeten innerhalb von zwei Tagen. Auch die Rotalgen müssen daher als mögliche Nahrungsquelle für *Theodoxus* ausgeschlossen werden.

Höhere Pflanzen. Die Flußdeckelschnecke wird nicht allein in Aquarien sondern auch im Freiland gelegentlich auf Wasserpflanzen angetroffen (Jaeckel 1952, Frömming 1956). Eine Verletzung der Blattoberfläche mit der Radula ist jedoch mit Sicherheit auszuschließen, da ich weder Fraßspuren auf Blättern noch Gewebestücke im Magen nachweisen konnte. Nur mögliche Aufwuchsalgen – wie z. B. Diatomeen oder Grünalgen (Chlorophyceen) – können von der Blätteroberfläche abgeweidet werden. Da jedoch die

Chlorophyceen für *Theodoxus* generell unverdaulich sind und weiterhin auch die Diatomeen von diesem mehr oder weniger glatten Freßgrund unverletzt verschluckt werden dürften und daher unter diesen Substratbedingungen gleichfalls nicht verdaut werden (s. Kap. V), finden die Flußdeckelschnecken auf den Blättern wohl kaum eine ertragreiche Nahrungsquelle. So ließen sich die Tiere in Aquarien auch nur für begrenzte Zeit auf Wasserpflanzen halten; gleiches bestätigen die Beobachtungen von Frömming (1956). Es darf daher bezweifelt werden, daß *Theodoxus* im Freiland allein auf Wasserpflanzen sitzend den Individualzyklus abschließen kann. Die natürliche ökologische Nische von *Theodoxus* ist die litorale Steinregion. Es ist allein denkbar, daß besonders an den Brandungsufern der Seen – vielleicht bei zeitweilig herrschenden, ungünstigen Sauerstoff- oder Temperaturbedingungen – vereinzelte Tiere vom steinigen Untergrund an Wasserpflanzen vorübergehend aufsteigen und hierbei möglicherweise auch von abgerissenen Pflanzenteilen verschleppt werden. An den von mir bisher untersuchten *Theodoxus*-Standorten fand ich jedoch auch bei vorhandenem Pflanzenwuchs in der Umgebung die Tiere stets auf dem Steingrund.

## V. Diatomeenverdauung und Substratbeschaffenheit

Aus den Freilandbefunden konnte geschlossen werden, daß pennate Diatomeen die natürliche Nahrung für *Theodoxus* sind. Umso erstaunlicher war das Ergebnis der ersten Fütterungs- und Aufzuchtversuche mit Diatomeen in Glasschalen und -aquarien: Obwohl die Tiere die bewachsenen Glaswände fleißig abweideten, ließen sie sich nur für kurze Zeit halten (durchschnittlich 3—6 Wochen bei Zimmertemperatur). Magen-, Darm- und Kotballenuntersuchungen zeigten, daß die von den Glasflächen aufgenommenen Diatomeen unverletzt und unverdaut den Darm passierten und für die Ernährung von *Theodoxus* bedeutungslos waren. Die Diskrepanz zwischen den Freilandergebnissen und diesen Fütterungsversuchen erschien zunächst wenig verständlich. Eine unerwartete Deutung ermöglichten erst Fütterungsversuche, bei denen die Freilandbedingungen in der Art nachgebildet wurden, daß den Tieren auch im Laboratorium rauhe Steinflächen als Freßgrund geboten wurden. Im Gegensatz zu den auf Glasflächen gewonnenen Ergebnissen fanden sich hier von dem Großteil der abgeweideten Diatomeen nur zertrümmerte Kieselschalen ohne Zellinhalt im Magen und Darm wieder. Darüber hinaus konnte bei diesen auf steinigem Substrat und ausschließlicher Diatomeenfütterung gehaltenen Tieren nach kurzer Zeit sowohl eine Zunahme des Körpergewichtes als auch

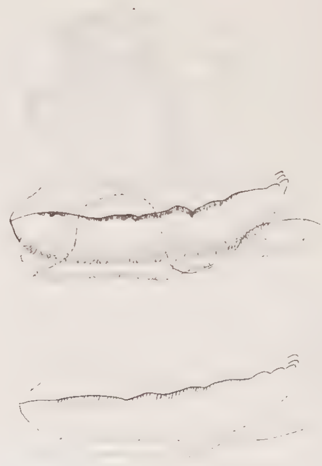
ein Schalenzuwachs verzeichnet werden, so daß eine gute Verdauung der Diatomeen bewiesen war. In einem besonders günstigen Beispiel wuchs eine Schnecke innerhalb von 100 Tagen von 0,8 mm (Schalengröße beim Ausschlüpfen aus dem Kokon) bis auf 7,2 mm (etwa durchschnittliche Schalenendgröße der Werratiere) heran (weitere Zuchtbedingungen: 25 °C; Medium: 3,7 ‰ Salzgehalt); im Freiland benötigen die Flußdeckelschnecken infolge der ungünstigen Temperatur- und Ernährungsverhältnisse einen wesentlich längeren Zeitraum bis zum Erreichen der Endgröße, in der Werra durchschnittlich zwei Jahre (Ulrich & Neumann, 1956). Die Versuche zeigen zweierlei: 1. die Diatomeen sind tatsächlich die natürliche Nahrung für *Theodoxus*, die sämtliche Anforderungen erfüllt, 2. für den Aufschluß der Diatomeennahrung ist die Nahrungsaufnahme von einem steinigen Substrat unbedingte Voraussetzung.

Für die Analyse dieser Beziehung zwischen der Diatomeenverdauung und der Substratbeschaffenheit bieten sich zwei Erklärungsmöglichkeiten an: 1. die zerbrechlichen Diatomeenschalen werden bereits während der Nahrungsaufnahme durch den kräftigen Zug der Radula über den rauhen Untergrund mechanisch zerkleinert; 2. die Diatomeen werden unverletzt mit der Radula eingekehrt und in einer Art Kaumagen – u. U. mit Hilfe der gleichzeitig vom Steingrund aufgenommenen mineralischen Partikel – zermahlen.

Gegen die zweite Deutung spricht bereits der anatomische Befund, daß ausgesprochene Kaumägen, wie sie bei Basommatophoren (z. B. *Limnaea stagnalis*, Heidermanns 1924) und Opistobranchiern auftreten, von Prosobranchiern bisher nicht bekannt geworden sind (Ankel 1936). Allerdings erwähnt Ankel (1936, S. 161) bei der Besprechung der Magenwand der Prosobranchier: „es kommen platten- oder zahnartige Kutikularbildungen von erheblicher Dicke vor (z. B. *Crepidula*, *Theodoxus*), die möglicherweise mechanisch auf die Nahrungsmasse einwirken." Die auf der vorderen Magenwand von *Theodoxus* befindliche „Kutikularplatte" kann jedoch bei einer Zerkleinerung der Diatomeenschalen keine Rolle spielen; sie wird vielleicht bei der Sortierung der Nahrungsbestandteile von Bedeutung sein oder möglicherweise angelagerten Verdauungsfermenten entsprechen. Den einwandfreien Nachweis einer fehlenden Kaufunktion des *Theodoxus*-Magens konnte schließlich Jantzen anhand von Fütterungsversuchen und Untersuchungen des Mageninhalts erbringen. Jantzen verglich das Zahlenverhältnis von unverletzten zu zerbrochenen Diatomeen im Vormagen, der die frischaufgenommene Nahrungsmasse locker gelagert enthält, und im Endmagen, in welchem die Nahrungsmasse zusammengepreßt und die Vorverdauung der Algen abgeschlossen wird. Es ergab sich, daß das Zahlen-

verhältnis im Vor- und Endmagen stets das gleiche war, und zwar unabhängig davon, ob die angebotenen Diatomeen mit mineralischen Partikeln (Quarzkörnern, Kalkkristallen) vermengt waren oder nicht. Eine Zertrümmerung der Diatomeenschalen im Magen von *Theodoxus* muß daher – auch bei Anwesenheit mineralischer Hartbestandteile – ausgeschlossen werden. Der Prozentsatz verletzter Diatomeenschalen hing wiederum in allen Versuchen allein von der Oberflächenbeschaffenheit des Freßgrundes ab. Bei Verfütterung der Diatomeen auf glatten Glasflächen (mit und ohne mineralische Partikel) lag der Anteil verletzter Diatomeen zwischen 0 und 10 %, bei Verfütterung auf rauhem Steingrund (Kalkstein, Buntsandstein) und auf im Sandstrahlgebläse aufgerauhten Glasscheiben waren 40 bis 100 % der Diatomeen zerbrochen. Die Diatomeen werden also bereits während der Nahrungsaufnahme durch die Reibungskräfte, die bei der Bewegung der Radula auf einem rauhen Freßgrund auftreten, mechanisch zerkleinert. Da die Schnecken auch bei reiner, auf aufgerauhten Glasflächen angebotenen Diatomeen-Nahrung ohne mineralische Beimengungen normal wuchsen, darf die ernährungsbiologische Bedeutung des Steinuntergrundes allein in der rauhen Struktur seiner Oberfläche gesehen werden. Die mineralischen Partikel werden somit bei der Nahrungsverarbeitung auch als Ballaststoffe nicht erforderlich sein; ihre Aufnahme ist vermutlich eine unwesentliche Begleiterscheinung beim Abweiden der Steine.

a



b

Abb. 3 4. Zwischenzahn von *Theodoxus fluviatilis*, mit intakter (a) und mit abgenutzter Zahnkante (b). Vergr. 330 x.

Die entscheidende Leistung der Radula, die Diatomeen bereits während des Freßaktes mechanisch zu zerkleinern, kann nur auf der Tätigkeit der mächtigen 4. Zwischenzähne beruhen. Diese zeigen auch in den vorderen, ältesten Querreihen erhebliche Abnutzungsspuren an den Zahnrändern (Abb. 3b). Für einen erfolgreichen Biß ist es notwendig, daß die Radula relativ kräftig den Freßgrund bearbeitet[1]). Dieses läßt sich einmal daraus entnehmen, daß abgemagerte und geschwächte Tiere nicht mehr die ausreichende Kraft hierfür aufbringen können und auch von rauhen Flächen die Diatomeen unzerbrochen abweiden. Zum anderen sind die vierten Zwischenzähne der aufeinanderfolgenden Querreihen für eine Rhipidoglossenradula ungewöhnlich fest ineinandergefügt (Abb. 3), so daß sie, durch ihre großen und flächigen Basalplatten zusätzlich gegen die elastische Basalmembran abgestützt, einer erheblichen mechanischen Beanspruchung leicht standhalten dürften. Für eine optimale Zertrümmerungsarbeit (etwa 100 % der aufgenommenen Diatomeen) ist es weiterhin erforderlich, daß der Diatomeenrasen dünnschichtig (eine Zellage) ist; bei mehrschichtigen und lockeren Diatomeenrasen werden ein Großteil der Kieselalgen (bis über 50 % s. o.) den Reibungskräften nicht ausgesetzt und unverletzt aufgenommen. Den Randzähnen dürfte, wie von ANKEL bereits erkannt wurde, allein die Aufgabe zukommen, die vom Freßgrund aufgelokkerten und zerkleinerten Diatomeen quantitativ einzufegen und den 4. Zwischenzähnen, denen nach Passieren der Knickkante vermutlich auch die hauptsächliche Transportleistung zufällt, zuzuführen.

Zusammenfassend kann festgestellt werden, daß die Diatomeen, die natürliche Nahrung von *Theodoxus*, nur dann verdaut werden, wenn die Kieselschalen durch die Radula auf einem rauhen Freßgrund mechanisch zerkleinert werden.

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[1]) Die bei den einzelnen Arten verschiedene Bewegungsrichtung des Radulaknorpels während des eigentlichen Freßaktes (s. Anmerk. S. 135) ist bisher im Hinblick auf die Leistungen der Radula wenig berücksichtigt worden. Es darf aber damit gerechnet werden, daß die zur schlundwärts gerichteten Radulabewegung entgegengesetzte (*Theodoxus*, *Viviparus*, *Gibbula*) bzw. gleichgerichtete (*Littorina*, *Emarginula*, Pulmonaten) Knorpelbewegung für die mechanische Einwirkung der Radula auf den Freßgrund nicht ohne ernährungsbiologische Funktion ist. Eine der Radulabewegung entgegengesetzte Knorpelbewegung hat, wie MÄRKEL (1958) anhand eines Vergleichs der Bißspuren von *Viviparus* und *Littorina* belegte, eine größere Zahnspurdichte und damit eine intensivere Bearbeitung des Freßgrundes zur Folge.

Die Fütterungsversuche haben gezeigt, daß die rhipidoglosse Kiemenschnecke *Theodoxus fluviatilis* zahlreiche Algen aus verschiedenen systematischen Klassen ohne Rücksicht auf die Verdaubarkeit vom Freßgrund aufnimmt. Die Nahrungswahl wird daher vorwiegend oder allein durch die mechanische Leistungsfähigkeit ihres Freßapparates bestimmt. Bei Berücksichtigung der Nahrungsverarbeitung ergibt sich jedoch, daß der Flußdeckelschnekke eine bedeutend geringere Anzahl von effektiven Nahrungsquellen offen stehen, im Freiland sogar im wesentlichen nur eine einzige, nämlich die pennaten Diatomeen. Die zahlreichen ein- bis wenigzelligen Grünalgen (Chorococcales) und die Zieralgen (Desmidiales) sind ernährungsbiologisch ohne Bedeutung; sie sind sämtlich unverdaulich. Sehr wahrscheinlich ist die Unverdaubarkeit der Grün- und Zieralgen ernährungsphysiologisch in erster Linie auf das Fehlen von Cellulasen zurückzuführen, so daß die Schnecken die starken, cellulosehaltigen Zellmembranen dieser Algengruppen enzymatisch nicht abbauen und somit den nährstoffreichen Zellinhalt nicht erlangen können. Hierfür sprechen auch die mit den Volvocalen erzielten Ergebnisse (s. S. 139), bei denen die Membranen gleichfalls unverdaut bleiben. Nach den Untersuchungen von Florkin & Lozet (1949, zit. n. Buddenbrock 1956) an dem cellulosespaltenden Kropfsaft von *Helix pomatia* darf damit gerechnet werden, daß auch bei den Schnecken – in Übereinstimmung mit den an Wiederkäuern gewonnenen Befunden – nur solche Arten Cellulosen verwerten können, die über symbiontische, cellulasebildende Bakterien im Verdauungstrakt verfügen. Von besonderem ernährungsphysiologischem Interesse ist in diesem Zusammenhang der Hinweis, daß im *Theodoxus*-Magen, wie die Ergebnisse über den Abbau der hemicellolusehaltigen Zellmembranen der Cyanophyceen zeigen (S. 139), im Gegensatz zu den fehlenden Cellulasen vielleicht ein hemicellulosespaltendes Ferment vorhanden ist. Die Auflösung der aus Pektinschleim bestehenden extrazellulären Scheiden der Cyanophyceen (Metzner 1955, zit. Frey-Wyssling 1959) läßt weiterhin auf pektinspaltende Enzyme rückschließen. Auch die Hauptfutterquelle von *Theodoxus*, die Kieselalgen, ist für die Schnecke ernährungsbiologisch wertlos, soweit nicht die Kieselschale bei der Nahrungsaufnahme mechanisch verletzt und der Zellinhalt für die Verdauungsenzyme freigelegt wird. Die Aufgabe der Zerkleinerung der Diatomeenschalen fällt der Radula zu. Die Radula vermag jedoch diese Leistung nur dann zu erfüllen, wenn die Schnecke die Kieselalgen von einem rauhen Substrat abraspeln kann. Derartige Substratverhältnisse findet die Schnecke im Freiland allein auf einem

geeigneten Steinuntergrund vor. Die ökologische Einnischung von *Theodoxus* in die litorale Steinregion ist damit vorwiegend ernährungsphysiologisch zu deuten. Eine stabile Steinregion ist für die Entwicklung einer *Theodoxus*-Population unbedingte Voraussetzung; sie liegt im Süßwasserbereich in Fließgewässern und an Brandungsufern zahlreicher Seen (z. B. in Schleswigholstein) vor. Das Vorkommen an diesen Standorten ist nicht, wie vielfach leicht vermutet wird, auf das dort gleichfalls herrschende erhöhte Sauerstoffangebot zurückzuführen; die durch Gefälle (bzw. Wind) bedingte Wasserströmung (bzw. -turbulenz) garantiert in erster Linie, daß ein vorhandener Steingrund nicht durch Sedimente abgedeckt wird. Auch die in undurchlüfteten Schalen durchgeführten und bereits über mehrere Jahre reichenden Zuchtversuche mit *Theodoxus* belegen, daß die Schnecke keine extremen Sauerstoffansprüche stellt.

Die ernährungsphysiologischen Potenzen von *Theodoxus* sind jedoch nicht allein auf die Diatomeen beschränkt. Wenigstens können ausgewachsene Tiere von fädigen Cyanophyceen (Hormogonales), solange sie keine dichten und verschleimten Rasen bilden, Stücke abzupfen und gut verdauen. Weiterhin lassen sich auch von verdaubaren Flagellaten (*Chlamydomonas*) unter besonderen Bedingungen Überzüge auf dem Freßgrund erzielen. Diese Potenzen dürften, wie aufgeführt (S. 139 u. 140), im Freiland ohne wesentliche Bedeutung für eine Dauerbesiedlung sein, sie können jedoch im Labor bei Zuchtversuchen mit *Theodoxus* ausgenutzt werden. Die zuletzt von SCHERMER genannten Hinweise (S. 137) auf eine animalische Kost von *Theodoxus* entbehren genauerer Belege und widersprechen meinen im Freiland und Laboratorium gesammelten Befunden sowie den Funktionsmerkmalen der Rhipidoglossenradula. *Theodoxus* ist sicher kein Fleischfresser. Wie die über mehrere Generationen bei reiner Algenernährung durchgeführten Zuchtversuche belegen, ist auch ein Zusatz tierischer Nahrung – wie er zum Beispiel für das Gedeihen von *Limnaea stagnalis* und *Physa acuta* notwendig sein soll (FRÖMMING 1956) – nicht erforderlich. Allerdings könnte damit gerechnet werden, daß die Flußdeckelschnecke beim Abweiden des Steinuntergrundes auch Protozoen (besonders sessile Formen, wie z. B. Carchesien, oder Amoeben) aufnimmt. So ist in der Werra, besonders in den Wintermonaten, häufig ein reicher Carchesienaufwuchs auf den Steinen zu finden. Über eingehende Beobachtungen zu dieser Frage sowie über die Aufnahme und Verdauung geringer Bakterien- und Detritusmengen verfüge ich nicht; eine wesentliche ernährungsbiologische Bedeutung wird aber Protozoen und Bakterien sicher nicht zugesprochen werden können. *Theodoxus* ist ein ausgesprochener Algenfresser. Um

allerdings die vieldeutige Bezeichnung „Algen" zu vermeiden und um die besonderen Bau- und Leistungsmerkmale der *Theodoxus*-Radula sowie die ernährungsphysiologischen Befunde zu berücksichtigen, ist *Theodoxus fluviatilis* zutreffender als ein Diatomeenfresser zu bezeichnen.

Die an *Theodoxus* gewonnenen Befunde über die Diatomeenverdauung führen auf die Frage, inwieweit andere Schnecken, die als Schlammfresser oder Strudler gleichfalls Diatomeen aufnehmen und weder über einen Mechanismus der Diatomeenzerkleinerung, wie er bei *Theodoxus* vorliegt, verfügen, noch einen im Dienste der Diatomeenzerkleinerung stehenden Kaumagen besitzen, die Diatomeen überhaupt ernährungsphysiologisch verwerten können. Fütterungsversuche mit der ernährungsphysiologisch zwischen Strudlern und Schlammfressern stehenden *Bithynia tentaculata* ergaben, daß „sowohl ein Teil der Grünalgen als auch der Diatomeen den Darmtraktus unverdaut und völlig lebensfähig verlassen" (SCHÄFER, 1953, S. 260). Leider wurde nicht mehr geprüft, inwieweit *Bithynia* überhaupt einen Teil der aufgenommenen „Grünalgen"- und Diatomeennahrung verdaut und bei reiner Algenernährung (ohne pflanzlichen und tierischen Detritus) allein durch Luxuskonsumption den für das Wachstum notwendigen Energiebedarf gewinnen kann. Der Befund von SCHÄFER erinnert in jedem Fall sehr an die Ergebnisse der an *Theodoxus* durchgeführten Fütterungsversuche mit den chlorococcalen Grünalgen und den auf glatten Freßgrund angebotenen Diatomeen. Er läßt vermuten, daß nicht nur für *Theodoxus* sondern auch für andere Kiemenschnecken sowohl „Grünalgen" (aufgrund fehlender Cellulasen) als auch Diatomeen (soweit diese unverletzt in den Verdauungstraktus gelangen und dort nicht mechanisch zerkleinert werden können) ernährungsphysiologisch bedeutungslos sind. Vielleicht ist *Bithynia* im Hinblick auf die Nahrungsauswertung in erster Linie ein reiner Detritusfresser.

Es kann abschließend gefragt werden, in welchem Umfang die Ergebnisse über die Radulafunktion von *Theodoxus* auf andere rhipidoglosse Kiemenschnecken übertragen werden können. Ein Vergleich mit *Gibbula cineraria* L. und *Emarginula crassa* Sow. (ANKEL 1938, EIGENBRODT 1941) zeigt, daß innerhalb der Rhipidoglossa mannigfache Abwandlungen auftreten. So sind sowohl bei *Gibbula* als auch bei *Emarginula* sämtliche Zwischenzähne in ihrer Größe und Differenziertheit relativ einheitlich. Eine Zahnstruktur, wie sie beim 4. Zwischenzahn von *Theodoxus vorliegt*, fehlt bei beiden Arten. Dagegen besitzt *Emarginula* einen kräftigen, dolchartig gebogenen Zahn, der innerhalb einer Zahnreihe seitlich neben den Zwischenzähnen liegt und während eines Freßaktes nach Passieren

der Knickkante mit den Randbürstenzähnen medianwärts über der Radula eingeklappt wird; er ist vermutlich mit dem 1. Randbürstenzahn der anderen Rhipidoglossa zu homologisieren. Wie bereits von EIGENBRODT ausgesprochen wurde, werden bei *Emarginula* die Zwischenzähne wohl keine Kratz- oder Schabarbeit leisten können; auch bei *Gibbula* hinterlassen sie zumindest in den Bißspuren keinerlei Andeutungen. Der Dolchzahn von *Emarginula* wird nach EIGENBRODT'S Beobachtungen vermutlich beim Fressen an höheren Pflanzen verwandt; allerdings wäre bei einem eingehenderen Studium der Ernährungsbiologie dieser Schnecke auch die Funktion der beiden Kiefer, welche *Emarginula* im Gegensatz zu *Theodoxus* besitzt, zu berücksichtigen. Der Vergleich läßt erkennen, daß bei der Rhipidoglossenradula – abgesehen von den für diesen Typ charakteristischen und in Arbeits- und Wirkungsweise gleichartigen Randzähnen – eine auffallende Mannigfaltigkeit im Zahnbau besteht, die in ihren einzelnen Beispielen zum Teil an Differenzierungen erinnert, wie sie uns in ausgeprägter Form bei anderen Radulatypen begegnen. So besitzt der 4. Lateralzahn von *Theodoxus* Funktionsmerkmale eines Dokoglossenzahnes und der Dolchzahn von *Emarginula* die eines Taenioglossenzahnes. Diese Vielseitigkeit im engeren Verwandschaftskreise wird für die Deutung der ernährungsbiologischen Differenzen und der ökologischen Grenzen zwischen den einzelnen Arten von entscheidender Wichtigkeit sein.

Kann die ökologische Einnischung von *Theodoxus fluviatilis* in die litorale Steinregion vorwiegend ernährungsphysiologisch gedeutet werden, so wird jedoch die Freilandverteilung weiterhin sowohl durch physiographische und biotische als auch durch verbreitungsgeschichtliche Faktoren mitbestimmt. Unter den physiographischen Faktoren sind der Salzgehalt sowie die Temperatur zu nennen (NEUMANN 1960 und unveröffentlicht); auch die relative Ionenzusammensetzung ist von Einfluss (SEGERSTRÅLE 1945, NEUMANN 1960). Eine zusammenfassende Darstellung wird vorbereitet.

## ZUSAMMENFASSUNG

Die Arbeitsweise und die Leistungen der Rhipidoglossenradula von *Theodoxus fluviatilis* werden durch die kräftigen 4. Zwischenzähne und die Randbürstenzähne bestimmt. Die 4. Zwischenzähne lockern im wesentlichen die dem Freßgrund anhaftenden oder aufliegenden ein- bis wenigzelligen Algen (Diatomeen, chlorococcale und konjugate Grünalgen), die Randzähne fegen das gelockerte Nahrungsgut quantitativ zusammen. Fädige Grünalgen (z. B.

Cladophorales) und Gewebeteile höherer Pflanzen werden nicht abgebissen bzw. abgeschabt.

Die Diatomeen werden nur verdaut, wenn die Kieselschalen bereits bei der Nahrungsaufnahme mechanisch zerkleinert werden. Diese Zerkleinerung erfolgt allein auf einem Substrat mit rauher Oberfläche; sie wird durch die während des Bisses zwischen 4. Zwischenzähnen und Substrat auftretenden Reibungskräfte erzielt.

*Theodoxus* wurde bei reiner Diatomeenernährung über mehrere Generationen gezüchtet. Tierisches Eiweiß ist als Zusatzkost nicht erforderlich. Mit besonderen Hilfsmaßnahmen kann *Theodoxus* im Laboratorium auch mit Cyanophyceen oder besonders mit Flagellaten (*Chlamydomonas*), die den Schnecken an den im Freiland besiedelten Standorten nicht zur Verfügung stehen, ernährt werden.

Sämtliche Grünalgen mit stärkerer Cellulosewandung (Chlorococcales, Conjugatae) sind unverdaulich. Die Unverdaulichlichkeit beruht vermutlich auf einem Fehlen von Cellulasen im Verdauungstraktus. Die Zellmembranen und extrazellularen Scheiden der Cyanophyceen, die aus Hemicellulosen und Pektinen aufgebaut sind, werden im Magen aufgelöst.

*Theodoxus* ist ein reiner Diatomeenfresser. Die ökologische Einnischung in die litorale Steinregion ist vorwiegend ernährungsphysiologisch begründet und erklärt das Vorkommen in Fließgewässern und an Brandungsufern stehender Süßgewässer sowie der Ostsee.

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# Distribution of Riffle Insects of the Firehole River, Wyoming

by

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(with 5 figs.)

## Introduction

In a previous paper (Armitage, 1958) consideration was given to the quantitative distribution of the riffle insect fauna of the Firehole River, Wyoming. Attention was focused on the relationship of standing crop, as expressed by weight, of the insects to bicarbonate alkalinity and temperature. The physical composition of the stream bottom was shown also to influence the level of standing crop. Standing crop variations result from the differences in distribution of the organisms that make up the standing crop. The purpose of this paper is to examine the qualitative and quantitative distribution of several taxonomic (e.g., family, species) groups composing the insect fauna of the riffles.

The author was able to study the fauna in the early spring and late fall because of the support provided by a National Science Foundation fellowship. A grant from the Gans Fund, Bethany College, West Virginia, helped defray some of the expenses of field operations.

The author wishes to express his appreciation for the cooperation given him by the personnel of the National Park Service, especially those of Yellowstone National Park. Special thanks are due to Park Naturalist David deL. Condon for his efforts in making the study possible and for his continued support whenever needed.

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## STUDY AREA

Although the study area was described fully previously (ARMITAGE, 1958), a brief description seems appropriate here. The Firehole River rises in Madison Lake and flows in an essentially northerly direction, cutting through a plateau of Tertiary rhyolite lava (HAGUE, 1887). The river flows through the main hot spring basins of Yellowstone National Park. Alteration of the rhyolite by the hydrothermal activity has made it much less resistant to erosion (BAUER, 1948) and likely has had a major role in determining the course of the streams in the hot spring area. The Firehole River receives a total discharge of 54.9 ft.$^3$/sec. from the hot springs (ALLEN & DAY, 1935). From this it would be expected that chemical and temperature changes would occur in the water as it flowed through the geyser basins. That this is indeed true is illustrated in Fig. 1. It should be noted that the downstream changes are not progressive at all sampling stations. The variation is probably the result of the influence of tributaries of the Firehole River that enter it at different places as the Firehole River flows through the hot spring basins. For example, the Little Firehole River, that enters the Firehole River between Above Biscuit and Below Biscuit stations, had a marked diluting effect (ARMITAGE, 1958, Table I).

## METHODS

Nine sampling stations were established in riffle areas above and below major influxes of hot spring water into the river. Each sampling station was named for a nearby geographical feature, usually a hydrothermal area. It was possible to collect from all the stations in a single day, except for a few instances in the late fall and in the spring when inclement weather made two or three days necessary to complete the sampling. On several trips, two samples were taken at each station. Usually one sample was collected from each station during each trip. The samples were collected with a modified square-foot sampler (HESS, 1941). The collected material was emptied into a white

TABLE I.

*Number of Samples of Each Bottom Type at Each Sampling Station*

| | Rubble | Bedrock | Gravel | Gravel-Bedrock | Gravel-Rubble | Rubble-Bedrock |
|---|---|---|---|---|---|---|
| Firehole River | | | | | | |
| Lone Star | 2 | 3 | | | 9 | 1 |
| Lion | 6 | 8 | | | | 1 |
| Riverside | 8 | 4 | 2 | | 1 | |
| Above Biscuit | 5 | 7 | | | 2 | 1 |
| Below Biscuit | 2 | 5 | 2 | 2 | | 4 |
| Fountain Freight Bridge | 5 | 8 | | | 2 | |
| Midway | 11 | 1 | | | 3 | |
| Ojo Caliente | 1 | 14 | | | | |
| Below Nez Perce | 3 | 6 | 1 | 3 | 2 | |
| Nez Perce Creek | 1 | 1 | | 1 | 1 | 2 |
| Upper Gardiner River | 3 | | | | | 2 |
| Lower Gardiner River | 5 | | | | | |
| Lava Creek | 4 | | | | 1 | |
| Black-tail Deer Creek | | | | | | 3 |

bottom pan and sorted. The insects were preserved in 70 percent alcohol to which a few drops of formalin were added.

The physical nature of the substrate was determined following a general scheme of classification (NEEDHAM, 1938). The bedrock of the Firehole River, however, differs from previously described substrates. This bedrock is lava that is very irregular, has many cracks and crevices, and often has projections or humps about the size of a piece of rubble. The number of samples of each bottom type at each sampling station is shown in Table I. Temperature was taken with a Taylor thermometer at the level of the sample. pH was determined in the field with the Hellige Colorimetric Comparator. Current velocities were measured at several stations with a calibrated Clarke-Bampus sampler (Table II).

TABLE II.

*Current velocities, as determined by means of a calibrated Clarke-Bumpus sampler, from four stations in the Firehole River. The l/sec values are for a cross-section area of 116.8 cm².*

| | |
|---|---|
| Lone Star | 3.7 l/sec |
| Lion | 6.0 l/sec |
| Riverside | 4.2 l/sec |
| Midway | 6.0 l/sec |

The organisms were identified at the University of Wisconsin by the use of standart keys (PENNAK, 1947, 1953; NEEDHAM, et al, 1935; ROSS, 1944; FRISON, 1935). After identification, each species was counted and weighed on Roller-Smith 100 or 1000 mg precision balances and tabulated for permanent reference (ARMITAGE, 1954). The sum of the numbers and weight of each organism that will be discussed in this paper are presented for each sampling station in Table III. The sums are based on all the samples collected.

Additional information was obtained about the various factors influencing the distribution of the riffle insects by surveying several other streams in Yellowstone National Park.

The Gardiner River receives an influx of hot water from the Hot River, the main run-off channel from the Mammoth Hot Spring Terraces. Samples were collected about 5 miles above and 1 mile below the junction of the Hot and Gardiner Rivers. Three samples were collected from each sampling station on the same day in the fall and two were collected from each sampling station on the same day in the spring.

Lava Creek and Black-tail Deer Creek are east of the Mammoth Hot Springs area and do not receive any water from hot springs. The sampling procedure for these streams was the same as for the Gardiner River, except that samples were collected from Black-tail Deer Creek only in the fall.

Nez Perce Creek rises to the east of the Firehole River and enters the Firehole River below the Lower Geyser Basin. Hot springs are found several places along its course. Six samples, three at each of two locations, were collected on the same day in the fall.

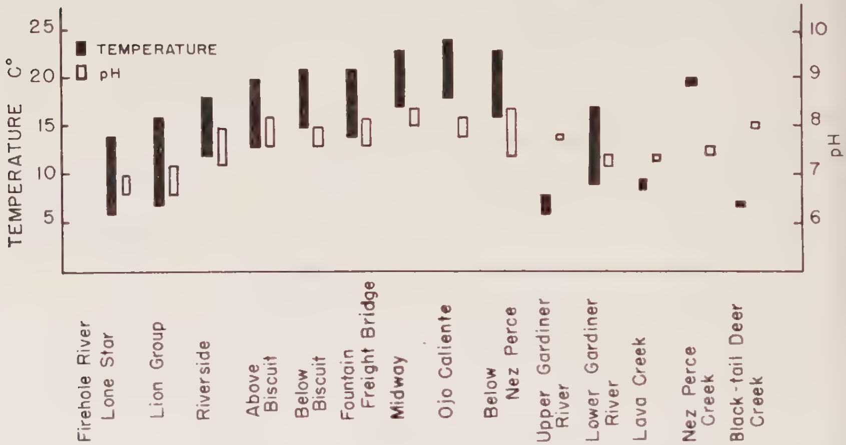


Fig. 1. The range of temperature and pH for all sampling stations in the Firehole River and the other streams. The temperature data are based on 17 records for each station of the Firehole River taken not less than once a week July to October, 1952 and in May, 1953; 2 records from the Gardiner River and Lava Creek, one taken in May and one, in September and one record from Black-tail Deer Creek and one from Nez Perce Creek, both taken in September. The pH data are based on the same number and distribution of records as for temperature except that 8 records were taken from the Firehole River, 3 in July, 2 in August, and one each in September, October and May.

The temperature ranges of these streams (Fig. 1) are not directly comparable with those of the Firehole River as temperatures were not taken during the summer when maximum temperatures would have occurred. However, the comparison of the temperatures taken in September and in May between the Firehole River and the Lower Gardiner River indicate that the temperature characteristics of the Lower Gardiner River were more nearly like those of the Above

Biscuit station of the Firehole River. The temperature characteristic of Nez Perce Creek was like that of the lower Firehole River stations. Therefore, the Lower Gardiner River and Nez Perce Creek will be considered as "warmer". The temperatures of the remaining streams were like those of the upper Firehole River and these streams will be considered "colder."

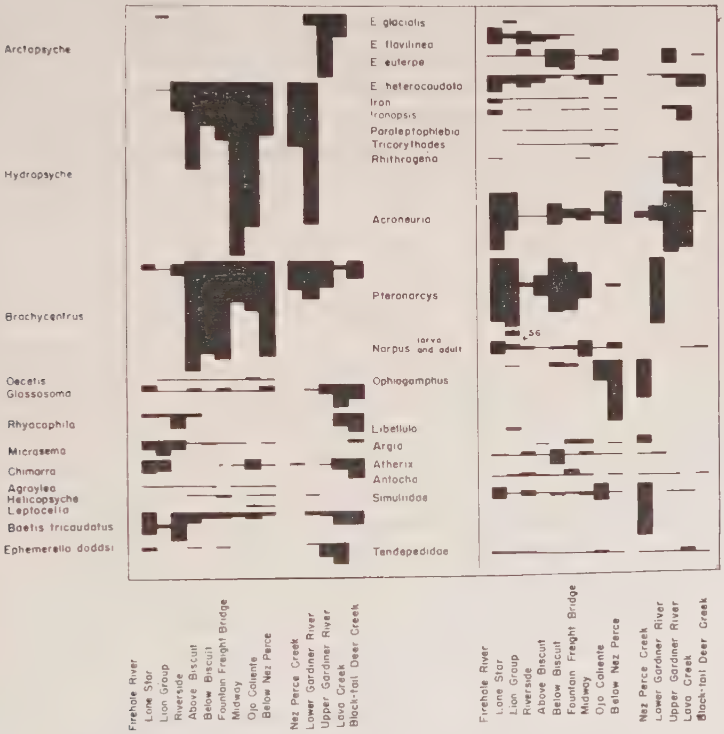


Fig. 2. The relative average weight of 32 taxa for each of the sampling stations of the Firehole River, Gardiner River, Lava Creek, Nez Perce Creek and Black-tail Deer Creek. The relative average weight of an organism at a sampling station is the total weight of the organism in all the samples collected at the sampling station divided by the total weight of all the organisms in all the samples collected at the sampling station times 100.

In any study of this sort the adequacy of the sampling procedure needs close attention. Needham & Usinger (1956) showed that a prohibitively high number of square foot samples were necessary to provide significant data on total numbers and total weights of bottom organisms. However, these same authors also demonstrated that the commonest genera were readily detected and that two or three

samples "would be sufficient to insure that at least one representative of each would be present" (NEEDHAM & USINGER, 1956, p. 396). In the present study fifteen amples were collected from each of the sampling stations in the Firehole River. However, these were scattered from early May until the middle of October. Thus those taxa with longer periods of larval existence would likely have greater representation in the samples. Since the sampling tended to be concentrated into spring, summer, and autumnal seasons, conclusions regarding qualitative distribution probably can be made with some degree of confidence as sufficient samples were taken in each season to ensure the detection of common forms. As an added precaution against bias resulting from inadequate sampling, uncommon forms will not be discussed, except in a few instances where the distribution of an uncommon form was so restricted that it probably has significance.

## ANALYSIS OF INSECT DISTRIBUTION

The total numbers and total weights of 33 taxa are presented in Table III. The relative abundance as determined by relative average weight of thirty-two forms at each of the sampling stations is shown in Fig. 2. The relative average weight of an organism at a given sampling station is the total weight of the organism in all the samples collected at that sampling station divided by the total weight of all organisms in all the samples collected at that sampling station times 100. Relative average weight corresponds to relative-dominance as used by plant ecologists (CURTIS & MCINTOSH, 1950). Relative average weight is used instead of average weight in order to eliminate differences in relative abundance due to differences in the level of standing crop. For example, species A has an average weight of 1 g at each of two stations, 1 and 2. But the standing crop at station 2 is 5 times larger than the standing crop at station 1. Therefore, all other factors being equal, species A should have an average weight of 5 g at station 2. Since it does not, station 2 is in some way less favorable (e.g., substrate, temperature) to species A than station 1. Thus, the relative average weight of an organism at a sampling station is more indicative of its reactions to the environment than is its absolute average weight.

For the purpose of discussing the distribution of the riffle insects, it is convenient to divide the Firehole River into colder and warmer waters. Inspection of Fig. 1 shows that the highest temperatures of the two upstream stations barely overlap the lowest temperatures of the three furthest downstream stations. The temperatures of the four

midstream stations overlap those of the upstream and downstream stations. Therefore, the upper part of the Firehole River will be considered as colder and the lower part as warmer. The use of colder and warmer, then, is relative and applies only to the distribution patterns of the Firehole River. These patterns can first be arranged into five groups.

In the Firehole River, *Arctopsyche* was found only at Lion Group. *Arctopsyche* was also found in Lava Creek and in the Upper and Lower Gardiner River, having a lower relative average weight in the Lower Gardiner than in the Upper Gardiner. *Ephemerella glacialis* and *Libellula* were found only at the Lion Group. *E. grandis* (Table III) was found at Lion Group and Riverside. *Rhyacophila* had higher relative average weights in the upper part of the Firehole River and in Lava and Blacktail Deer Creeks. *Micrasema* also had higher relative average weights in the upper part of the Firehole River and was present also in Black-tail Deer Creek. *E. doddsi* and *Rhithrogena* were found in very low numbers in warm water areas, but their highest relative average weights were in Lava Creek and the Upper Gardiner River. All of these insects of Group 1 have a common pattern of having their highest relative average weights in colder water and of having little or no representation in warmer water.

*Baetis tricaudatus*, *E. flavilinea*, *E. heterocaudata*, *Iron*, *Ironopsis* and the Tendepedidae were found throughout the Firehole River with a few minor exceptions. But all of them tended to have a steady downstream decrease in relative average weight that coincides with the downstream increase in temperature (Fig. 1). Their distributions in other streams showed similar patterns. For example, *B. tricaudatus* and *E. heterocaudata* were found in warmer and colder waters, but had higher relative average weights in the colder waters. *Chimarra* presents an interesting problem. It had a discontinuous distribution in the Firehole River, being found in the two stations furthest upstream and in the three stations furthest downstream. It is possible that two species were present, one occurring in colder water and one occurring in warmer water. Since the distribution in the other streams indicates a preference for cold water, the genus is included with this group. *Acroneuria* was found at every station sampled. The higher relative average weights were associated with the colder waters. At only one warm water station, below Nez Perce, did it achieve a high relative average weight. Therefore, it is also included with this group. These taxa form Group 2. All of them were found distributed over a wide range of temperature, but had higher relative average weights in the colder waters.

All of the members of Group 3 were rare in the colder waters. *Hydropsysche* was not found in any of the colder water except for a

TABLE III.

*The total numbers and total weights (mg), summed for all samples, of 33 taxa for each sampling station of the Firehole River and for the other streams that were surveyed. Total numbers in the upper row and total weight (mg) in the lower row opposite each taxon.*

| Firehole River: | Lone Star | Lion Group | Riverside | Above Biscuit | Below Biscuit | Fountain Freight Bridge | Midway | Ojo Caliente | Below Nez Perce | Nez Perce Creek | Lower Gardiner River | Upper Gardiner River | Lava Creek | Black-tail Deer Creek |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Arctopsyche* | | 2 | | | | | | | | | 13 | 62 | 11 | |
| | | 58 | | | | | | | | | 607 | 530 | 272 | |
| *Hydropsyche* | | 3 | 142 | 642 | 190 | 353 | 1054 | 385 | 243 | 211 | 950 | | | |
| | | 22 | 419 | 3164 | 1397 | 1309 | 7746 | 4476 | 1756 | 614 | 7170 | | | |
| *Brachycentrus* | 5 | 4 | 16 | 197 | 228 | 202 | 140 | 101 | 263 | 44 | 184 | 23 | 3 | 2 |
| | 20 | 5 | 157 | 4060 | 3101 | 2359 | 1841 | 1368 | 3257 | 341 | 1957 | 216 | 49 | 19 |
| *Oecetis* | | 1 | 3 | 6 | 6 | 9 | 4 | 27 | 8 | | | | | |
| | | 2 | 15 | 23 | 38 | 24 | 14 | 43 | 25 | | | | | |
| *Glossosoma* | 23 | 3 | 4 | 19 | | 24 | 9 | 4 | 29 | | 25 | 13 | 44 | 9 |
| | 23 | 7 | 2 | 84 | | 49 | 2 | 2 | 164 | | 86 | 76 | 294 | 41 |
| *Rhyacophila* | 5 | 20 | 18 | 9 | | | | | | | 2 | 1 | 12 | 7 |
| | 9 | 117 | 194 | 47 | | | | | | | 14 | 1 | 130 | 55 |
| *Micrasema* | 60 | 406 | 142 | 14 | 89 | 21 | 2 | | 8 | | 66 | 5 | | 18 |
| | 37 | 373 | 129 | 12 | 58 | 31 | 6 | | 13 | | 164 | 3 | | 10 |
| *Chimarra* | 7 | 35 | | | | | 3 | 98 | 2 | 4 | | 2 | 8 | 3 |
| | 51 | 261 | | | | | 10 | 259 | 11 | 20 | | 10 | 110 | 56 |
| *Agraylea* | | 2 | 10 | 2 | 8 | | 2 | 20 | 5 | | | | | |
| | | 1 | 11 | 1 | 9 | | 1 | 11 | 2 | | | | | |
| *Helicopsyche* | | | | 1 | 4 | 23 | | 9 | 13 | | 15 | | | |
| | | | | 1 | 8 | 44 | | 7 | 25 | | 19 | | | |
| *Leptocella* | | | | | | | | 3 | 4 | | | | | |
| | | | | | | | | 43 | 35 | | | | | |
| *Baetis* | 49 | 55 | 295 | 230 | 207 | 154 | 241 | 149 | 114 | 6 | 67 | 4 | 48 | 7 |
| *tricaudatus* DODDS | 79 | 57 | 408 | 361 | 176 | 133 | 166 | 177 | 128 | 4 | 142 | 35 | 136 | 38 |
| *Ephemerella* | 5 | | | 1 | | 1 | | | | | 1 | 10 | 21 | 3 |
| *doddsi* NEEDHAM | 11 | | | 5 | | 1 | | | | | 1 | 111 | 233 | 3 |
| *E. grandis* EATON | | 2 | 3 | | | | | | | | | | | |
| | | 116 | 243 | | | | | | | | | | | |

| River: | Star | Group | | Biscuit | Biscuit | Bridge | | Calcite | Feree | Creek | River | River | [illegible] | [illegible] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *E. flavilinea* | 8 | 16 | 32 | 19 | 6 | 2 | 8 | | | | | | | |
| McDUNNOUGH | 63 | 75 | 192 | 202 | 123 | 14 | 142 | | | | | | | |
| *E. euterpe* | 6 | 44 | 43 | 10 | 122 | 66 | 23 | 30 | 53 | | 2 | 19 | | 12 |
| TRAVER | 10 | 62 | 108 | 16 | 586 | 486 | 106 | 122 | 356 | | 17 | 112 | | 6 |
| *E. heterocaudata* | 45 | 31 | 71 | 66 | 39 | 25 | 115 | 39 | 2 | | 5 | 17 | 36 | 35 |
| McDUNNOUGH | 65 | 186 | 173 | 293 | 86 | 41 | 181 | 270 | 1 | | 4 | 21 | 138 | 39 |
| *Iron* | 11 | 8 | 3 | 2 | 1 | 15 | 37 | | 5 | | | | | |
| | 17 | 24 | 2 | 22 | 1 | 52 | 79 | | 5 | | | | | |
| *Ironopsis* | 8 | | 2 | | | 1 | 6 | | 1 | | | 6 | 16 | |
| | 16 | | 11 | | | 1 | 23 | | 1 | | | 21 | 166 | |
| *Paraleptophlebia* | | 10 | 23 | 1 | 5 | 1 | 11 | | 5 | | | | | |
| | | 4 | 28 | 1 | 2 | 1 | 3 | | 3 | | | | | |
| *Tricorythodes* | | | 1 | 1 | 1 | 2 | 1 | 28 | 3 | | | | | |
| | | | 4 | 4 | 1 | 4 | 1 | 51 | 4 | | | | | |
| *Rhithrogena* | 3 | | | | | | 1 | | | | 1 | 36 | 48 | 5 |
| | 4 | | | | | | 2 | | | | 2 | 263 | 411 | 3 |
| *Acroneuria* | 11 | 22 | | 19 | 37 | 14 | 18 | 11 | 24 | 3 | 54 | 18 | 26 | 8 |
| | 243 | 1027 | | 25 | 653 | 200 | 452 | 95 | 1085 | 49 | 704 | 524 | 654 | 8 |
| *Pteronarcys* | 1 | 21 | 1 | 2 | 11 | 23 | 8 | | 5 | 5 | 41 | | | |
| | 270 | 4436 | 70 | 772 | 1770 | 1143 | 1182 | | 91 | 500 | 3452 | | | |
| *Narpus* larva | 86 | 312 | 111 | 61 | 156 | 173 | 115 | 91 | 22 | 12 | 46 | 4 | 6 | 9 |
| and adult | 53 | 194 | 83 | 46 | 117 | 113 | 79 | 65 | 17 | 8 | 42 | 3 | 6 | 8 |
| *Ophiogomphus* | | 1 | | | 2 | 2 | | 4 | 9 | 3 | | | | |
| | | 31 | | | 161 | 69 | | 594 | 2092 | 377 | | | | |
| *Libellula* | | 1 | | | | | | | | | | | | |
| | | 1260 | | | | | | | | | | | | |
| *Argia* | | | | 1 | | 5 | 6 | | 1 | 3 | | | | |
| | | | | 28 | | 100 | 183 | | 24 | 73 | | | | |
| *Atherix* | 1 | 2 | 5 | 1 | 34 | 5 | 7 | 1 | 1 | 2 | 5 | | | |
| | 4 | 3 | 60 | 22 | 498 | 39 | 149 | 1 | 3 | 6 | 73 | | | |
| *Antocha* | 1 | 10 | 16 | 18 | 5 | 23 | 9 | | 21 | 1 | 5 | 2 | | 2 |
| | 4 | 46 | 51 | 49 | 21 | 130 | 50 | | 49 | 2 | 22 | 4 | | 5 |
| *Simuliidae* | 19 | 32 | 29 | 17 | 93 | 47 | 152 | 534 | 9 | 278 | | 1 | 8 | |
| | 45 | 38 | 75 | 39 | 91 | 35 | 159 | 471 | 10 | 498 | | 4 | 2 | |
| *Tendepedidae* | 16 | 119 | 44 | 64 | 72 | 57 | 94 | 101 | 74 | 5 | 11 | 4 | 40 | 4 |
| | 10 | 83 | 22 | 21 | 33 | 14 | 32 | 50 | 30 | 4 | 5 | 5 | 50 | 2 |

few individuals at Lion Group. *Helicopsyche* was distributed through the middle and lower part of the Firehole River and in the Lower Gardiner River. *Oecetis*, *Paraleptophlebia* and *Tricorythodes* were never very abundant and were found only in the Firehole River, the first two from the Lion Group downstream and the other from Riverside downstream. *Leptocella* also was collected only from the Firehole River, being restricted to the two station furthest downstream. *Ophiogomphus* had a wider distribution than *Leptocella*, but also achieved high relative average weights only at the two furthest downstream stations of the Firehole River and, in addition, in Nez Perce Creek. *Argia* had its highest relative average weight in Nez Perce Creek with slightly lower levels at Fountain Freight Bridge and Midway stations in the Firehole River. Thus the members of this group are characterized either by their absence in colder waters and/or by their higher relative average weights in the warmer waters.

*Brachycentrus*, *Atherix* and *Antocha* were found at all of the stations of the Firehole River, with one exception. All of them had higher relative average weights in the warmer parts of the river. *Atherix* was absent from the other cold water streams, but the other three taxa were present in both cold and warm water streams. However, a preference for warm water is evident. *Brachycentrus* had higher relative average weights in Nez Perce Creek and the Lower Gardiner River and showed a marked decrease in Lava Creek. *Antocha* was absent from Lake Creek. *E. euterpe* may also belong to this group. Its distribution in the Firehole River and its absence in Lava Creek indicate a warm water preference. However, its high relative average weight in the Upper Gardiner River and its absence from Nez Perce Creek indicate a cold water preference. Since many more samples were taken from the Firehole River, it seems likely that more significance should be placed on those data and *E. euterpe* is included with this group. All of these taxa forming Group 4 were found distributed over a wide range of temperature, but had higher relative weights in the warmer waters.

The remaining taxa form Group 5. *Glossosoma*, *Pteronarcys*, *Narpus*, *Agraylea* and the Simuliidae did not show any particular pattern of distribution in relation to temperature.

Further examination shows that Groups 1 and 2 and Groups 3 and 4 share common characteristics. Although the taxa composing Groups 1 and 2 vary widely in their distributions, as seen in Fig. 2 and Table III, all of them show a preference for colder water. This colder water preference is evidenced either by means of a limited distribution, such as that of *Rhyacophila*, or by means of a higher relative average weight in colder water, such as that of *E. flavilinea*. The taxa of groups 3 and 4 also vary widely in their distributions,

but indicate a preference for warmer waters. This preference is demonstrated either by means of a restricted distribution, such as that of *Leptocella*, or by means of a higher relative average weight in warmer water, such as that of *Brachycentrus*.

In summary, three distributional patterns based on temperature are evident. Sixteen taxa prefer colder waters; twelve taxa prefer warmer waters; five taxa show no preference.

Other studies have shown that temperatures influences the distribution of stream insects. DODDS & HISAW (1925) studied the altitudinal zonation of species of Plecoptera, Ephemeroptera, and Trichoptera in South Boulder Creek, Colorado. They concluded that temperature was the chief climatic factor responsible for the zonation. WHITNEY (1939) described a direct correlation between the resistance of Ephemeroptera nymphs to high temperatures and the temperatures of their natural habitats. IDE (1935) found an increase in the number of species of mayflies from the source downstream. This was correlated with a greater fluctuation in temperature downstream. The increase in number of species was due to the addition of new species. Only two species found near the source dropped out downstream. SPRULES (1947) obtained a direct correlation between the total change of species at successive stations and the average water-temperatures in summer. The total change was derived by summing the number of species eliminated and the number of species added at each station. SPRULES also concluded that the total number of species was influenced by temperature, but that other factors influenced the total number of any one species.

Several of the forms presented in Fig. 2 show wide fluctuations within the temperature range that they prefer. *Hydropsyche* has its higher values in the Firehole River at the Biscuit, Ojo Caliente, and Midway stations. All of these had areas of rapid current although the only current measurement among these was at Midway (Table II). *Hydropsyche* builds nets on the tops of stones or on the surface of bedrock. The nets are fastened by means of a salivary cement and often found where the water is the swiftest (NEEDHAM, 1938). The current also seems necessary for the net spinning. Larvae from swift-flowing water are immobilized in still waters at higher oxygen concentrations than larvae from slow-flowing waters. However, they are able to tolerate a low oxygen concentration, provided the water is moving (PHILIPSON, 1954).

The lower values for *Hydropsyche* occurred at Lion Group and Riverside. These probably result from year to year changes in the winter temperature at these stations. On November 15, 1952 the temperature at the Lion Group was 36°F (2.2°C) and at Riverside, 40°F (4.4°C). The temperature was 32°F (0°C) at the Lion Group

and 36°F (2.2°C) at Riverside on December 1 (MARLER, personal communication). There are many hot-spring-seepages along the river bank between the Lion Group and Riverside stations which probably warm the river sufficiently to allow a population of *Hydropsyche* to develop except during severe winters. No *Hydropsyche* were found at either station in 1950 and 1951. It is interesting to note that the winter of 1952 was considered mild (MARLER, personal communication) and that *Hydropsyche* was found in September and October of 1952 at Riverside and at both stations in the spring of 1953 after the mild winter. *Hydropsyche* was more abundant at Riverside (Table III, Fig. 2) which has a higher temperature characteristic.

The higher values for *Brachycentrus* occurred at stations Above Biscuit, Below Biscuit, Fountain Freight Bridge and Below Nez Perce. Below Biscuit and Below Nez Perce characteristically had slow-flowing waters throughout nearly all their cross-sections. In addition, qualitative observations indicated that *Brachycentrus* was more abundant in areas of slow-moving current in those stations of the Firehole River characterized by both slow and fast-flowing current in the stream's cross-section. In slow-moving current, *Brachycentrus* was found attached to nearly every available surface, including rocks, mosses, sticks, etc. But where current was swift, *Brachycentrus* was on the underside of rubble.

The nymph of *Tricorythodes* burrows among the stems and rhizoids of mosses growing on the river bottom. Its greatest relative average weight was at Ojo Caliente where there was a very prolific growth of moss. A similar moss growth was found at the Lion Group, but this form was absent there. Thus it appears that the upstream distribution was limited by temperature, but other factors, such as the distribution of the moss, contributed to the population fluctuations within the temperature range.

The discontinuous distribution of *Chimarra* was mentioned previously. It was most abundant at Ojo Caliente and Lion Group (Table III). At the former station, it was found among the gravel and sand around the bases of the mosses. Thus its distribution may be closely related to the distribution of plants as for *Tricorythodes*. However, this does not account for its absence from the middle part of the Firehole River where the less abundant *Tricorythodes* was found.

*Paraleptophlebia submarginata* is found only in summer warmed waters where it avoids the direct action of strong current by supporting itself in streaming water plants (PLESKOT, 1953). In the Firehole River, *Paraleptophlebia* was found at all temperature ranges except the lowest and highest. The highest average temperature also coin-

cides with the very rapid current and bedrock stream bottom of Ojo Caliente. *Paraleptophlebia* was collected in 15 samples, 13 of which were from a rubble bottom. The organism could escape the current on the underside of a piece of rubble, but this environmental characteristic was rare at Ojo Caliente (Table I). It appears that its absence there was not because of high temperature, but because it was unable to avoid the swift current.

The nymphs of *Ophiogomphus* are shallow burrowers in sand or gravel in the river bottom (Needham & Heywood, 1929). Its greatest relative average weight was at Below Nez Perce where the current was comparatively slow and where there were extensive deposits of sand and gravel (Table I). An examination of the individual samples of this station show that it was more numerous and larger in size in those samples in which there was enough gravel so that it was recorded as a major element of the bottom composition. It was not found in any rubble sample and was completely absent from those stations where the bottom was mostly rubble. High values for *Ophiogomphus* also were recorded at Ojo Caliente and in Nez Perce Creek. At Ojo Caliente it was found burried in the sand and gravel around the bases of the mosses and in Nez Perce Creek it was found in moderately rapid current buried in the gravel and vegetation.

Figure 3 further demonstrates the selectivity of certain forms for a particular bottom type. For the river as a whole through all seasons, thirty-seven rubble samples averaged 112.8 organisms weighing 919.7 mg/ft.$^2$ and fifty-six bedrock samples averaged 78.2 organisms weighing 369.9 mg/ft.$^2$. On the average, rubble contained 1.44 times the number of organisms weighing 2.48 times more. The Plecoptera, *Iron*, and *Ironopsis* all have much higher average weight-values on rubble than can be accounted for by differences in standing crop alone. *Iron* was found in 40 % of the rubble samples, but in only 4 % of the bedrock samples. *Ironopsis*, a much less common form, shows the same pattern. It was found in 15 % of the rubble samples and 4 % of the bedrock samples. The Plecoptera were found in 62 % of the rubble samples and in 30 % of the bedrock samples. *Iron* and *Ironopsis* show a slightly higher average number value than can be accounted for by standing crop values alone. However, the Plecoptera show a very slight numerical difference. This evidence indicates a very decided preference for rubble bottom instead of bedrock by these three forms. The similarity in average numbers of Plecoptera in bedrock and rubble presents an interesting situation. If the female stonefly lays eggs at random, there should be as many deposited on bedrock as on rubble. Since the form of bedrock is highly variable and often has bumps or knobs the size of a piece of rubble, some of it will present niches for the young stoneflies. As these nymphs

mature, they might be unable to find suitable living space and be washed into the river or eaten by predators. Thus the weight is always much lower because large larvae are never developed. The female might select the spot to deposit her eggs. If this selection is based on the configuration of the bottom (perhaps anything she can crawl behind), she might select those bedrock areas which are bumpy and show characteristics similar to rubble. Thus the larvae could

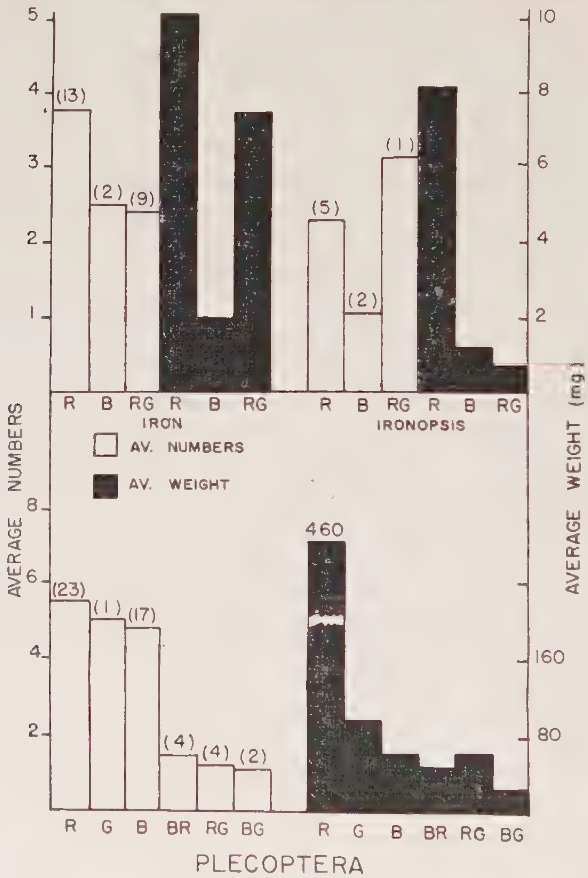


Fig. 3. The average number and average weight of *Iron*, *Ironopsis* and the Plecoptera on rubble (R), bedrock (B), gravel (G), rubble-gravel (RG), bedrock-rubble (BR), and bedrock-gravel (BG) substrates in the Firehole River. The number of samples from each substrate is indicated in parentheses at the top of the bars for average number. Average number and average weight were determined by summing the number and weight of the respective organism from all samples from each type of substrate and dividing by the number of samples from each substrate in which the organism was collected. Samples from all seasons and all sampling stations were lumped.

mature and all of the weight in bedrock samples would be derived from those variations of form of bedrock which have some characteristics of rubble. A very careful and detailed study of the habits and behavior of both the adult and nymphal stone-flies would be needed to answer this problem.

SPRULES (1947) recorded the species which emerged over different types of stream-bottom and recorded their numbers in several categories of abundance. His abundance-data are not corrected for the basic standing crop differences among the bottom-types. Nor did he separate adequately the effects of current and bottom-composition as he considered the two intimately related. But his data in some respects show very clear species orientation to a certain bottom type.

The reasons why some species orient to a certain bottom-type is not clear, but probably is related to available surface, food and oxygen requirements, and need for protection. A large Plecoptera could not live behind a grain of gravel smaller than itself. Species which need current to bring to them food or oxygen should be found on any bottom type that is large enough to give them support and which permits them to be exposed to the current. *Hydropsyche* was found in 78.3 % of the rubble samples and 80.3 % of the bedrock samples. *Hydropsyche* averaged 47 individuals weighing 309.2 mg per sample on rubble and 27.5 individuals weighing 225.4 mg per sample on bedrock. These differences in numbers and weight fall well within the standing-crop difference of the two bottom types. From this it is concluded that *Hydropsyche* does not orient to a particular bottom type as either type gives adequate support and exposure to current.

Little more can be said about the effects of current since a micro-current meter is needed to measure the current in which a particular insect lives. But a brief review of some of the literature may be of value in focusing attention on this problem. WINGFIELD (1939) found that some aquatic insects have a demand for current which constantly brings a fresh supply of oxygenated water to the respiratory surface rather than for a high dissolved oxygen-content. DODDS & HISAW (1924a) found that *Baetis tricaudatus* was present where the current was not more than 5 ft./sec. In this connection, it is worth noting that *B. tricaudatus* had its lowest values in the Firehole River where the rate of flow was high and its highest values where the rate of flow was slow (Table II, Fig. 2). DODDS & HISAW were unable to find any correlation between gill area and current rate, but did find that gill area varied inversely with the dissolved oxygen-content (1924b). In the discussion of the problem of the effects of current, WELCH (1952) quotes studies which indicated that some

may-flies and caddis-flies that thrive in currents have a higher consumption of dissolved oxygen than certain closely related non-current species of equal size. Also swift-water may-flies were found to be less resistant to oxygen deficiency than those in quiet water. The above discussion indicates some conflict in the role of current in gaseous exchange. Most gaseous exchange occurs cutaneously.

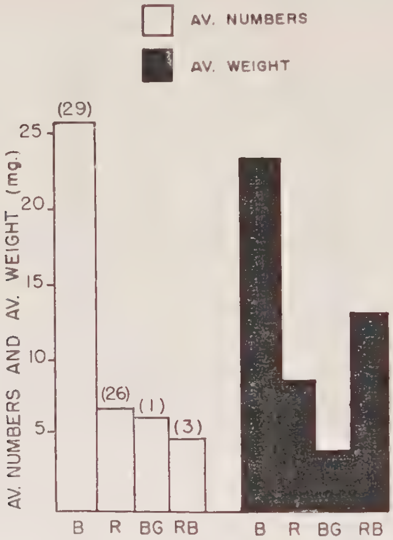


Fig. 4. The average number and average weight of larvae of the Simuliidae on various substrates. Symbols and average number and average weight as in Fig. 3.

Gills beat more rapidly under low oxygen concentrations, but it has not been conclusively demonstrated that they function in actual exchange. However, some evidence indicates that the gills may function at very low oxygen concentrations (WIGGLESWORTH, 1939).

WU (1931) concluded that the Simuliidae had an "inherent current-demand". Figure 4 shows that the Simuliidae have a definite preference for bedrock. They were collected from about the same number of bedrock and rubble samples. But they were about $4\frac{1}{2}$ times more numerous on bedrock than on rubble and weighed about 3 times more on bedrock. These differences are a striking reversal of the standing crop differences between rubble and bedrock mentioned previously. Most of the bedrock surface is in contact with the current and on other bottom types a smaller amount of the surface is in contact with the full force of the current. Thus there were more Simuliidae on bedrock because the bedrock had more surface exposed to the current.

One factor that may influence the distribution of bottom fauna but which is difficult to evaluate from the kinds of data collected in this study is interspecific competition. For example, the patterns of relative average weight of *E. euterpe* and *E. heterocaudata* tend to complement one another. Whenever one is high, the other is low. A square foot sample is probably too large a unit to analyze for interspecific competition as there is no way of determining if the organisms are found on the same or on different rocks, etc.

## Seasonal fluctuations of Taxonomic Groups

The seasonal fluctuation in numbers of twenty-four taxa is presented in Table IV. Five of the forms occurred in greatest numbers in the autumn; two, in the summer; fifteen, in the spring; two occurred in equal numbers in the spring and summer; and one occurred in equal numbers in the spring and autumn. Two may-flies, *Ephemerella grandis* and *E. glacialis* were found only in the spring, and *E. doddsi* was found only in the autumn. *E. doddsi* was found only in the autumn in the Lower Gardiner River, but was found in both spring and autumn in Lava Creek and the Upper Gardiner River. The absence of *E. doddsi* in the spring in the Firehole River and in the Lower Gardiner River may be a result of sampling error as it was present in very low numbers in these streams. Or, since it is a cold water form, it may have emerged in the warmer streams when the water was cooler prior to the collection of spring samples.

The seasonal fluctuations result from the nature of the life histories of the insects. Two examples illustrate this point. *B. tricaudatus* (Fig. 5) had its highest density in the fall, its lowest in the summer, and its intermediate value in the spring. The less numerous spring and summer individuals had higher average weights and the more numerous autumnal individuals had smaller average weights. From this it is concluded that the nymphs emerge in spring and early summer and the next generation hatches in late summer and early autumn. *Brachycentrus* had higher numbers in the summer with an almost complete absence of larvae in the autumn. This was correlated with pupation which reached its maximum in late August and early September.

## Riffle Insect Communities

There have been few attempts to describe the communities of bottom organisms of streams. Muttkowski (1929) divided mountain streams into three main categories; white water, clear rapids, and

Table IV.

*The average number of individuals of 24 taxa summed for all the nine sampling stations of the Firehole River. The spring average is based on 3 samples/station; the summer average is based on 6 samples/station; the autumnal average is based on 6 samples/station.*

| | Spring (May) | Summer (July-Sept. 14) | Autumn (Sept. 21-Oct. 12) |
|---|---|---|---|
| *Hydropsyche* | 301 | 125 | 226 |
| *Brachycentrus* | 79 | 143 | 2 |
| *Glossosoma* | 17 | 6 | 4.5 |
| *Micrasema* | 138 | 16 | 38 |
| *Chimarra* | 3 | 5 | 17 |
| *Agraylea* | 4 | 1.6 | 4.5 |
| *Rhyacophila* | 2.3 | 1.3 | 6 |
| *Baetis tricaudatus* | 69 | 60 | 153 |
| *E. euterpe* | 113 | 3.5 | 6.0 |
| *E. flavilinea* | 26 | 1.6 | 0 |
| *E. heterocaudata* | 110 | 4 | 11 |
| *E. grandis* | 1.6 | 0 | 0 |
| *E. glacialis* | .3 | 0 | 0 |
| *E. doddsi* | 0 | 0 | 1.1 |
| *Iron* | 18 | 4 | .1 |
| *Ironopsis* | 1.6 | 1.6 | .5 |
| *Paraleptophlebia* | 16 | 1.1 | .6 |
| *Tricorythodes* | 2.6 | 2.1 | 2.6 |
| *Rhithrogena* | 1 | .1 | 0 |
| *Ophiogomphus* | .6 | 1.5 | 1 |
| *Argia* | 1 | 1 | .5 |
| *Atherix* | 9.6 | 1 | 5.5 |
| *Narpus* larva | 88 | 57 | 70 |
| *Narpus* adults | 7.0 | 6.3 | 6.0 |

placid water. Shelford (1913) described the *Hydropsyche* or rapids formation. This is subdivided into three strata: the upper surface of stones, among the stones, and under stones. Ruttner (1953) writes of factors which alter the biocoenoses of a river, but does not describe the biocoenoses. The problems inherent in describing communities are discussed in Allee, et. al. (1949) and Andrewartha & Birch (1954). One point stands out above all others – the community boundaries are subjectively chosen by the observer. In recent years there has been a trend away from the concept of discrete communities (Curtis & McIntosh, 1951; Brown & Curtis, 1952; Whitaker, 1952; Curtis, 1955; Whitaker & Fairbanks, 1958). The continuum concept conceives of a continuously varying environment with ever changing species ranges along it. The data presented in this paper are not sufficient to make a definite contribution to either

concept of species aggregations. But certain inferences can be derived from the data.

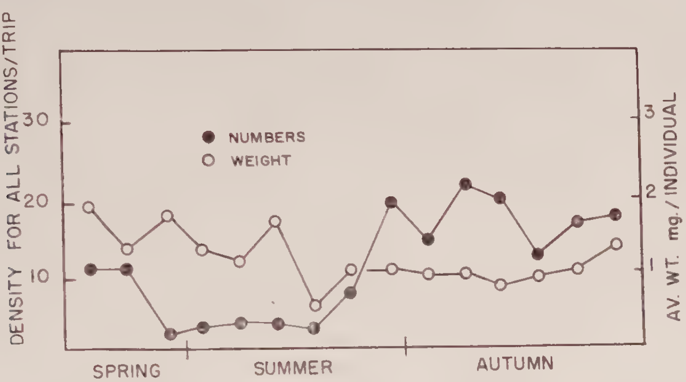


Fig. 5. The density and average weight per individual of *Baetis tricaudatus* in the Firehole River for spring, summer and autumn. Density is the average number per sample. Samples from all sampling stations and all bottom types were lumped for each sampling trip.

The data in Table IV show that there is a seasonal flux in the numbers of the taxa so that the composition of the community is continuously changing in time. The bar graphs of Figures 2, 3 and 4 show that the populations of species are changing in space. Some of these changes in space were related to temperature, composition of the substrate and current. But many of the changes are not understood because of lack of detailed studies of the species involved. When one considers these temporal and spatial distribution patterns and when one considers the fluctuating nature of the environment with its swift and slow currents, its eddies and its turbulence, with its intermingled rubble, gravel and bedrock, with its variations in water depth, it seems more likely that the stream habitat consists of a variety of ecological factors interacting in numerous and complex ways to produce many environmental gradients along which species are distributed.

## Summary

The Firehole River flows through the major hot spring basins of Yellowstone National Park. The runoff water from the hot springs changes the physical and chemical characteristics of the river as evidenced by the progressive downstream increase in temperature and pH.

Nine sampling stations were located in riffles above and below all

the major influxes of hot spring water into the river. One hundred thirty-five samples of bottom organisms were collected from all the stations from July through October 1952 and in May 1953. The organisms were identified, counted and weighed.

Four other streams in Yellowstone National Park were surveyed to gather more information about the factors influencing the ecological distribution of the stream insects.

*Arctopsyche*, *Rhyacophila*, *Micrasema*, *Ephemerella glacialis*, *E. grandis*, *E. doddsi*, *Rhithrogena*, *Libellula*, *Baetis tricaudatus*, *E. flavilinea*, *E. heterocaudata*, *Ironopsis*, *Iron*, *Chimarra*, *Acroneuria* and the Tendepedidae were considered to be forms that preferred colder water. *Leptocella*, *Ophiogomphus*, *Argia*, *Paraleptophlebia*, *Tricorythodes*, *Helicopsyche*, *Oecetis*, *Hydropsyche*, *Brachycentrus*, *Atherix*, *Antocha* and *E. euterpe* were considered to be forms that preferred warmer water. *Glossosoma*, *Agraylea*, *Narpus*, *Pteronarcys* and the Simuliidae were widely distributed and did not evidence any temperature preference.

The nature of the substrate and rate of water flow were discussed in addition to temperature as factors influencing the ecological distribution of stream insects.

The seasonal fluctuations in average numbers of twenty-three species or genera were described.

Although the data do not permit a direct contribution to the study of the community concept, they do indicate that the species occur along a continuously fluctuating environment and that discrete communities cannot be described.

## Zusammenfassung

Der Firehole Fluss ergiesst sich durch das Hauptbecken der heissen Quellen im Yellowstone National Park. Die Abflusswasser der heissen Quellen ändern die physikalischen und chemikalischen Eigenschaften des Flusses. Dies ist erwiesen durch die flussabwärts sich steigernden Temperaturen und pH.

Neun Untersuchungsstationen wurden oberhalb und unterhalb der wichtigsten Mündungen von heissem Quellwasser in dem Fluss in Stromschnellen angebracht. Hundert und fünfunddreissig Proben von Unterwasser-Lebewesen wurden von all diesen Stationen von Juli bis Ende Oktober 1952 und im Mai 1953 gesammelt. Diese Lebewesen wurden identifiziert, gezählt und gewogen.

Vier andere Ströme im Yellowstone National Park wurder ausserdem untersucht, um mehr Erkenntnisse über Faktoren, welche die ökologische Verbreitung der Flussinsekten bestimmen, zu sammeln.

*Arctopsyche*, *Rhyacophila*, *Micrasema*, *Ephemerella glacialis*, *E. grandis*, *E. doddsi*, *Rhithrogena*, *Libellula*, *Baetis tricaudatus*, *E. flavilinea*, *E. heterocaudata*, *Ironopsis*, *Iron*, *Chimarra*, *Acroneuria* und die Tendepedidae wurden als Arten, die kaltes Wasser vorziehen, erkannt. *Leptocella*, *Ophiogomphus*, *Argia*, *Paraleptophlebia*, *Tricorythodes*, *Helicopsyche*, *Oetis*, *Hydropsyche*, *Brachycentrus*, *Atherix*, *Antocha* und *E. euterpe* wurden als Arten, die warmes Wasser vorziehen, erkannt. *Glossosoma*, *Agraylea*, *Narpus*, *Pteronarcys* und die Simuliidae waren weit verbreitet und zeigten keinerlei Vorliebe für diese oder jene Temperatur.

Die Eigenart des Substrat und die Geschwindigkeit des Abflusses wurden neben Temperaturen als beeinflussende Faktoren in der ökologischen Verteilung der Flussinsekten erörtert.

Die jahreszeitlichen Schwankungen in der Anzahl der Insekten wurden von dreiundzwanzig Arten oder Gattungen beschrieben.

Obwohl die Ergebnisse keinen direkten Beitrag zur Aufklärung des Gruppenkonzepts bedeuten, so weisen sie doch darauf hin, dass diese Arten in einer sich ständig ändernden Umgebung vorkommen und dass isolierte Gruppen nicht beschrieben werden können.

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# Food Cycles in Sphagnous Bogs

by

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(with 1 fig.)

Sphagna produce the bulk of the plant production in bogs. Yet extremely few consumers of the sphagna are known. We found (SMIRNOV 1958, 1959) that there are no abundant species of animals specialized on the nutrition by the emersed sphagna. We also undertook the collection of the population of the submersed sphagnum to find if there are animals consuming it. The results of this part of work are published here.

This paper is a part of trophological investigations carried out by the Department of Hydrobiology of the Institute of Fish Industries under the leadership of Professor N. S. GAJEVSKAJA. The reading of the manuscript by Professor F. D. MORDUKHAY-BOLTOVSKOY is acknowledged.

As a typical water body overgrown by the submersed sphagnum the borrow pit on the raised bog on the northern shore of the lake Poletskoye was chosen (73 km West from Moscow). This borrow pit was 20 years old. It is almost entirely overgrown by *Sphagnum riparium* ÅNGSTR. with only small spaces of clear water. All the samples were taken from the same place of this borrow pit. The depth in the place of sampling is 1.8 m, the surface pH in summer 6.4. The sphagnum is submersed with only the heads emerging and standing 1—2 cm one from another. The length of the submersed parts is about 70 cm, the upper 12 cm are green, lower the leaves become brown. Under 50 cm the brown leaves and branches fall off.

Numerous algae are present among the sphagnum: filamentous *Oedogonium* sp., *Mougeotia* sp., *Gymnozyga moniliformis* EHRENB., desmids- *Staurastrum*, *Cosmarium*, *Xanthidium*, *Pleurotaenium*, naviculoid diatoms, protococcous *Oocystis borgei* SNOW. In places *Calla palustris* L. and sedges grow on the sphagnum. On the shores

the usual bog Angiosperms are to be found: *Chamaedaphne calyculata* MOENCH., *Ledum palustre* L., *Andromeda poliifolia* L., *Vaccinium uliginosum* L., *Oxycoccos quadripetalus* GILIB., *Eriophorum vaginatum* L., *Carex* sp. sp., *Drosera rotundifolia* L., *Pinus silvestris* L., *Betula* sp., *Populus tremula* L.

Many large-sized predators live among the submersed sphagnum – *Odonata* larvae, *Hemiptera*, sometimes beetles and their larvae. The submersed sphagnum is also inhabited by Chironomid larvae. *Cladocera* are abundant: *Acroperus harpae* (BAIRD), *Chydorus sphaericus* (O. F. MÜLLER), *Graptoleberis testudinaria* (FISCHER), *Rhynchotalona rostrata* (KOCH), *Ceriodaphnia setosa* MATILE, *Scapholeberis mucronata* (O. F. MÜLLER), *Simocephalus vetulus* (O. F. MÜLLER), *Acantholeberis curvirostris* (O. F. MÜLLER). *Cyclopoida*, *Rotatoria* (*Lecane* sp., *Monostyla* sp., *Trichocerca* sp., *Asplanchna* sp., *Bdelloidea*) are also present. *Rhizopoda* were abundant in all our samples.

As possible consumers of the sphagnum might be present only among Chironomid larvae we studied this group closer. To get the idea of the numbers of *Chironomidae* in the submersed sphagnum we washed the sphagnum from 1/4 $m^2$ (by small bundles) in a pail of water. Then the water with the washed off material was filtered through 0.5 mm mesh sieve. All the animals from the sieve were preserved in formalin and subsequently carefully picked out from the remnants of the sphagnum using the stereoscopic microscope. The numbers for separate species of the larvae are shown in table I.

The fluctuations of the numbers in this case may be explained by the emergence of the imagines, by the uneven distribution of the larvae, and by the difficulty of the complete collection of the larvae from the matted sphagnum stems. *Psectrocladius ex gr. psilopterus*, *P. ex gr. dilatatus*, *Chironomus plumosus* were also found in borrow pits by PANCRATOVA (1954).

To find the consumers of Sphagnum the *Nematocera* larvae were dissected and the food items in the gut contents were aproximately evaluated (SMIRNOV 1959a) (table II). The figures in the table designate the part of the corresponding food items from the whole volume of the food.

It is seen from the table that *Psectocladius ex gr. psilopterus* was the only consumer of the submersed sphagnum. Sphagnum constituted only 0.16 even in the food of this species, being present in the food only of 1/3 of the larvae. Only once the food consisted completely of the pieces of the living leaves of Sphagnum, twice they constituted 0.9 of the food, once 0.7. The most part of the food of *P. ex gr. psilopterus* (0.8) consisted of the filamentous algae. The other algae were present in many cases but in small quantity (*Stau-*

TABLE I.

*Species composition and per cent ratio of Nematocera larvae collected among Sphagnum riparium.*

| year | 1957 | | | | 1958 | | | |
|---|---|---|---|---|---|---|---|---|
| date | VII.8 | VII.15 | VIII.19 | IX.5 | VII.24 | VIII.3 | VIII.14 | VIII.19 |
| t°C of water | 19 | 26.5 | 20 | 16.5 | 27 | 23 | 17.5 | 17 |
| total number of larvae collected on 1/4 m² | 351 | 17 | 107 | 608 | 264 | 215 | 63 | 46 |
| *Ablabesmyia ex gr. monilis* L. | 33 | — | 67 | 38 | 28 | 38 | 57 | 9.1 |
| *A. ex. gr. lentiginosa* FRIES. | — | — | — | 0.1 | 4.6 | 7.5 | — | — |
| *Psectrocladius ex gr. psilopterus* KIEFF. | 36 | 18 | 13 | 41 | 23.4 | 22.4 | 19 | 68 |
| *P. ex gr. dilatatus* V.D. WULP. | — | — | — | — | 0.4 | — | — | — |
| *Corynoneura celeripes* WINN. | 21 | 18 | 1 | — | 12.1 | 14 | 1.6 | 4.6 |
| *Corynoneura sp.* | 2.3 | 5 | — | 1.2 | 12 | 3.3 | 4.8 | 2.3 |
| *Chironomus plumosus* L. | 7.7 | 59 | 19 | 19 | 18 | 12 | 14.4 | 11.4 |
| *larva of the group Palpomyia, Bezzia, Alluaudomyia* | — | — | — | 0.7 | — | 2.8 | 3.2 | 4.6 |
| *Chaoborus crystallinus* DE GEER | — | — | — | — | 1.5 | — | — | — |

TABLE II.

*Composition of food of non-predating Chironomidae larvae in the submersed Sphagnum riparium*

+ present in small quantity

1-mean for all larvae with food in the gut, 2-mean for the larvae with the given food item, 3-occurence per cent of the larvae with the given food item of all larvae with food

| larva | number dissected, length, dates of collecting | index | living Sphagnum | *Oedogonium sp.* | *Gymnozyga moniliformis* | *Mougeotia sp.* | other algae | detritus | pollen | animal fragments |
|---|---|---|---|---|---|---|---|---|---|---|
| *Psectrocladius* | 27 | 1 | 0.16 | 0.38 | 0.44 | | + | 0.02 | + | |
| *ex gr. psilopterus* | 2—3.5 mm | 2 | 0.44 | 0.4 | 0.49 | | + | 0.3 | + | |
| KIEFF. | 57.VII.8 | 3 | 35.7 | 75 | 82 | | 46 | 4 | 25 | |
| *P. ex gr. dilatatus* V. D. WULP. | 1 | | | | 0.2 | 0.8 | | | | |
| | 6.5 mm | | | | | | | | | |
| | 58.VII.24 | | | | | | | | | |
| *Chironomus plumosus* L. | 20 | 1 | 0.04 | 0.03 | 0.01 | 0.001 | + | 0.86 | + | 0.06 |
| | 2.5—6.5 mm | 2 | 0.14 | 0.23 | 0.03 | 0.06 | + | 0.86 | + | 1 |
| | 57.VII.8, VII.15, IX.5 58.VIII.14, VIII.19 | 3 | 21 | 29 | 11 | 5 | 52 | 95 | 18 | 9 |
| *Corynoneura celeripes* WINN. | 20 | 1 | | 0.15 | | | + | 0.85 | + | |
| | 1.5—2.5 mm | 2 | | 0.3 | | | + | 0.85 | + | |
| | 57.VII.8,58. VIII.19 | 3 | | 46 | | | 21 | 100 | 14 | |
| *Corynoneura* sp. | 12 | 1 | | 0.07 | 0.02 | | 0.2 | 0.71 | + | |
| | 1—1.5 mm | 2 | | 0.05 | 0.1 | | 0.4 | 0.71 | + | |
| | 57.VII.8 | 3 | | 50 | 17 | | 50 | 100 | 17 | |

*rastrum* sp., *Xanthidium* sp., *Euastrum* sp., *Oocystis borgei*, navicu- naviculoid diatoms). Pollen grains were also present.

The food of *Chironomus plumosus*, *Corynoneura celeripes*, and *Corynoneura* sp. consisted mostly of the detritus with the admixture of algae.

Of the predating chironomids *Ablabesmyia ex gr. monilis* were most numerous in the submersed sphagnum. In the borrow pit they fed on *Cladocera*, chironomid larvae, and other small arthropods (18 larvae dissected, length 2.5—5 mm, from the collection of 57.VII.8). The other predating *Nematocera* larvae were present in small numbers (*Ablabesmyia ex gr. lentiginosa*, *Chaoborus crystallinus*, *Heleidae*).

Thus the submersed sphagnum is consumed very little. The same is true of the emersed sphagnum. The main food sourses for non predators in the submersed sphagnous growths are the algae growing among Sphagnum and the detritus. The detritus-feeders in the raised bogs are some chironomid larvae, *Cladocera*, and *Rotatoria* (*Keratella*, *Polyarthra*) (Harnisch 1929, 1949, Zernov 1934, 1949, Berezina 1953). Järnefelt (1956) is of opinion that the detritus of the raised bog waters is of phytoplanktonic origin. If this is so then the nutrition of the detritus-feeders is based ultimately on the algae, and not on the sphagnum.

The bladderwort rather abundantly growing in the borrow pit catches *Crustacea* and chironomid larvae (Rodionova 1959).

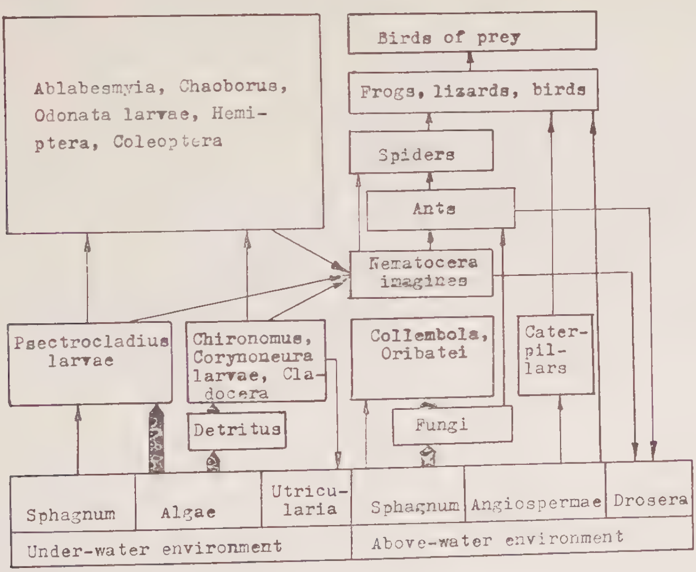


fig. 1.

For aerial environment of the sphagnous bogs there are the following data on the food interrelations. We showed (SMIRNOV 1958, 1959) that the dominating invertebrates living in the emersed sphagnum feed on the fungi growing on the decomposing sphagnum. The shrubs are eaten by caterpillars (PEUS 1932). The ants consume partly the fungi, partly *Diptera* and other invertebrates (SKWARRA 1929, MAAVARA 1955, 1955b). The spiders catch the small *Nematocera*, and after SKWARRA (1929) also the ants.

More than 3/4 of the catch of *Drosera rotundifolia* L. is not longer than 0.5—2 mm (MAAVARA 1955a, OLBERG 1955) and consists of the imagines of *Chironomidae*, *Heleidae*, *Lycoriidae* and *Hymenoptera* (FRIDOLIN 1932, MAAVARA 1955). WASMANN (1914) and SKWARRA (1929) observed that *Drosera rotundifolia* may catch the ants.

The frogs and lizards in the raised bogs consume insects and Angiosperms, berries and seeds including (KREN 1937, MAAVARA 1955a). The birds feed on insects, spiders, and berries. Some of the birds feed on the vertebrates (KREN 1937, KUMARI 1951, 1953). All described above data give reason to represent the main food interrelations in the sphagnous bog as shown in fig. 1.

## SUMMARY

The submersed sphagnum is populated by *Odonata* and *Chironomidae* larvae, *Hemiptera*, *Cladocera*, *Cyclopoida*, *Rotatoria* and *Rhizopoda*. Sphagnum-eaters might be found among *Nematocera* larvae. To find them the food cymposition of this group was studied. The dissections demonstrated that of 9 species of *Nematocera* larvae Sphagnum was present in the food only of *Psectrocladius ex gr. psilopterus*, the quantity of Sphagnum being 0.16 of the food volume. The main food of *non predating Nematocera* larvae living in the submersed Sphagnum consists of the algae and the detritus. The emersed Sphagnum is also eaten but little. The springtails dominating here feed mainly on the fungi growing on the decomposing Sphagnum. Our data and the data by other authors gave a possibility to respresent the main food interrelations in the sphagnous bogs as shown in fig. 1.

## Выводы

Подводные заросли сфагнума населены личинками стрекоз, хирономид, полужесткокрылыми, ветвистоусыми и веслоногими рачками, коловратками и корненожками. Поскольку возможными потребителями сфагнума могли быть личинки

двукрылых, обследовано их питание. Вскрытия показали, что из найденных 9 личинок *Nematocera* сфагнум присутствовал в пище только у *Psectrocladius ex gr. psilopterus* в количестве 0,16 от объёма пищи. Основной пищей не хищных личинок *Nematocera,* живущих в погружённом сфагнуме являются водоросли и детрит. В надводных зарослях сфагнума поедание его также невелико. Преобладающие здесь вилохвостки питаются в основном грибами, развивающимися на отмирающем сфагнуме. Полученные данные и данные других авторов позволили наметить схему основных пищевых связей в сфагновых болотах (рис. I).

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# Fish Vertebrae and Scales in a Sediment Core from Esthwaite Water (English Lake District)

by

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(with 2 figs. and 1 plate)

Mr. F. J. H. MACKERETH (Freshwater Biological Association) and Dr W. PENNINGTON, when examining a sediment core taken on 24 March 1959 from the lake called Esthwaite Water, found four fish vertebrae and some fish scales in one of the layers of the core. As this was the first time that fish remains had been found in a core taken by the Freshwater Biological Association the following account of the dating (by PENNINGTON) and identification (by FROST) of the remains is given.

The fish remains were found at a depth of 450 cm below the mud surface, in a core from the middle of Esthwaite water where the water is 14 m deep. The deposit in which they lay was grey clay – gyttja containing some organic matter, and immediately below the fish remains this clay-gyttja passed into the pinkish grey laminated clay which forms the basal deposit over the whole floor of the valley, and is interpreted as dating from the last main episode of the Quaternary glaciation. Detailed accounts of the stratigraphy and interpretation of the Esthwaite water deposits will be found in FRANKS & PENNINGTON (New Phytologist, in press). In the course of a detailed investigation of the Esthwaite deposit it has been found that in some places the conformable succession of organic deposits has been destroyed by slumping, and because the core in which the fish remains were found was seen to be one of these, no continuous series of samples for analysis was taken from this core.

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Fig. 1 illustrates its stratigraphy compared with the usual succession of deep-water deposits in Esthwaite as illustrated by a core taken 20 yd. (18.5 m) to the west. In the usual succession the main laminated glacial clay is overlain by late-glacial deposits which show the characteristic three-fold division into upper and lower clays separated by an organic mud representing the milder Allerød oscillation; above the upper clay lies a conformable succession of post-glacial deposits. On the usual British zonation scheme, based on pollen analysis, the late-glacial period comprises Zones I, II ,and III, and the post-glacial period Zones IV to VIII. The zone boundaries indicated on the second core in Fig. 1 are based on the complete pollen-analysis of this core by Dr. J. W. FRANKS.

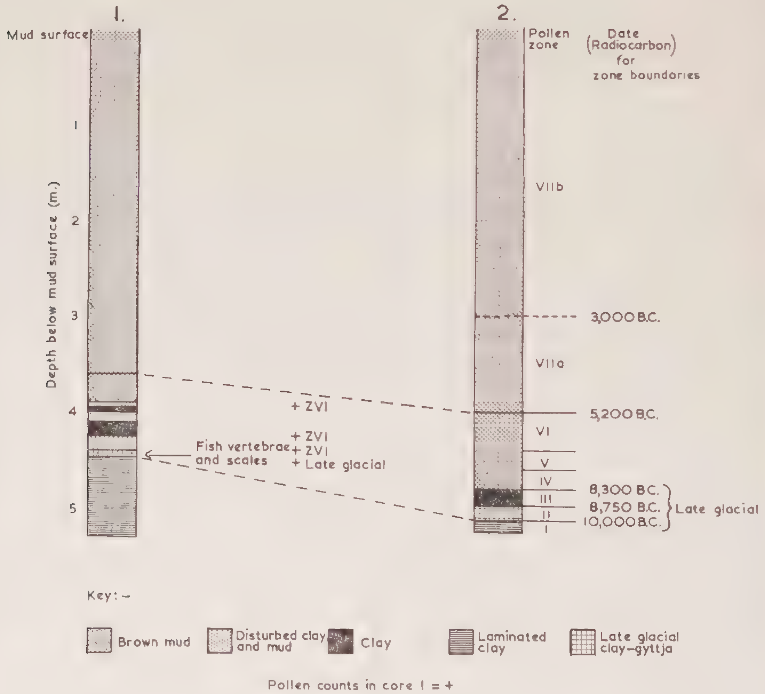


Fig. 1. Core 1, in which the fish remains were found, compared with Core 2 (from 20 yd., 18·5m. to the west) which shows the normal conformable succession of deposits.

In the core in which the fish remains were found it was at once apparent from the stratigraphy that, above the clay containing the fish, the succession of deposits was not that which has been described as usual. Directly above the fish remains occurred dark brown organic mud, in colour and consistency resembling the post-glacial

muds, and above this was a thick deposit of clay (390 to 426 cm) which in its upper part was obviously disturbed, since irregular chunks of organic mud were incorporated in the clay. Above 390 cm the core consisted of the usual dark-brown organic mud of post-glacial type, with a narrow clay band at 361 cm. There was no trace of the usual pale brownish-grey detritus mud of Zone II nor of the characteristic stony clay of Zone III, and the disturbed clay between 390 and 426 cm was different from any deposit previously found in Esthwaite Water.

The positions of the isolated samples which were withdrawn from this core for pollen analysis are indicated in Fig. 1. The deposit in which the fish remains were found yielded a typical assemblage of Late-glacial pollen types – viz. *Betula*, *Pinus*, *Salix*, *Juniperus*, *Filipendula ulmaria*, *Chenopodium*, *Thalictrum*, *Artemisia*, *Plantago*, and Compositae. Though the numbers were not great enough to make a significant count, this assemblage of pollen grains indicates that the fish remains are surrounded by mud of undoubted late-glacial age.

It is, however, impossible on this evidence to assign the fish bones to any particular horizon in the late-glacial period. Two pollen samples from the organic mud which overlay the fish remains yielded pollen counts typical of Zones VI (high *Corylus* and some *Ulmus*; dominant *Betula* and *Pinus*), and showed that this mud cannot possibly be assigned to Zone II. There must therefore be a considerable unconformity between the deposit containing the fish bones and the immediately overlying organic mud, which is itself overlain by a clay deposit showing obvious signs of disturbance. In the organic mud at 390 cm, immediately above this disturbed clay, the pollen assemblage is also characteristic of Zone VI.

The most probable interpretation is that the deposit in which the fish bones were found was formed *in situ*, (because of its downward continuity with the main laminated clay), and that much later, in Zone VI, slumping of deposits into a hollow in the lake floor at this point destroyed the conformable succession above this late-glacial deposit, and probably produced the peculiar mixed deposit between 390 and 426 cm by incorporating the late-glacial clay of Zone III into the still later organic muds of Zones IV, V and VI. Evidence of similar slumping during this period has been found in Ennerdale Water and Wastwater.

It therefore seems probable that the fish bones and scales date from the earlier part of the late-glacial period, before the spread of birch woodland in Zone II had led to recession of the herbaceous species, but it is not possible to say with certainty, on the available evidence. Recent radiocarbon dates for the British late-glacial period (Godwin,


Plate I. Fish vertebrae and scales in the core form Esthwaite Water.

a. Vertebra, seen from anterior articulating surface.
b. Vertebra, seen from posterior articulating surface.
c. Representative sample of scales.
d. Scale showing suggestion of an annulus (An.).

(Walker & Willis 1957, Godwin & Willis 1959), place the boundary between Zone I and Zone II at 10,000 B C., and the boundaries of Zone III at 8,750 B.C. and 8,300 B.C. respectively. This means that the most probable age for the fish bones and scales is between 10,000 and 12,000 years. There is little evidence as to what were conditions in the lake at that time.

There were four fish bones found in the one place in the core. They are vertebrae, and although each was taken out of the core separately the four vertebrae fit so well together that they are almost certainly consecutive in the backbone. The scales, about 40, were obtained by sieving the mud in the region of the bones. The vertebrae were almost black in colour, well preserved, strong and practically intact; each was 5.0 mm long. (Plate I. (a) & (b)). The scales were from 1.2—1.7 mm long, light brown in colour and very fragile, and had either bad centres or torn edges, or both; none was perfect (Plate I. (c) & (d)). As the bones and scales were found so close together it is assumed that they came from the same fish, which, from the shape and structure of the scales, is identified as belonging to the Salmonidae, most probably the trout (*Salmo trutta* L.) or the char (*Salvelinus alpinus* L.).

The shape of the core vertebrae, when compared with those forming the backbone of a brown trout and a char, shows that they were probably four of the most anterior of the caudal series, most likely the first in which the haemal arch bears a median spine and the three following it. Comparisons of the caudal vertebrae of trout and char from Windermere show no structural differences between the species nor at different sizes, but I have taken the precaution of comparing vertebrae from fishes of the same size as the, core fish' must have been. To determine the size of this fish I plotted, at Miss Kipling's suggestion, the diameter of vertebra against length of fish for char and trout of a wide range in size (Fig. 2), fitted a line by eye to the points and read off the length of fish corresponding to the diameter (6.0 mm) of the core vertebrae. This gave a fish of 40 to 45 cm; a trout of this length would weigh about $2\frac{1}{4}$ lb, a char I lb. 14 oz. The four core vertebrae were then compared with vertebrae from trout of 38 to 46 cm and from char of 37.5—41.5 cm (the last is the largest char available from Windermere); they showed equally good agreement with both species.

I sent the core vertebrae to Dr Trewavas of the British Museum (Natural History). She found that they corresponded very well with trout vertebrae in the Museum's collection of skeletons and were structurally similar to vertebrae of much smaller specimens of char of the species *Salvelinus colii*, *S. grayi*, and *S. perisii*. A skeleton of a *Salvelinus* (char) of about 27 cm showed a variant structure in the

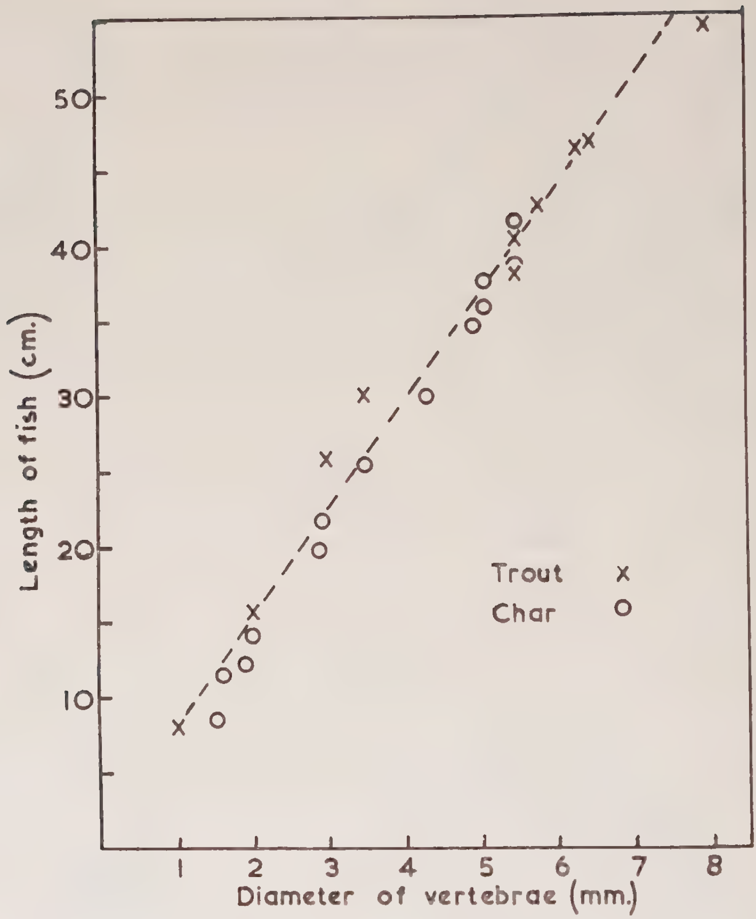


Fig. 2. Method of determining the size of the core fish (see tex

posterior abdominal and anterior caudal vertebrae, in that the anterior dorsal zygapophyses were each divided by a notch to form two peaks. Since this structure was undivided in the other char skeletons, both in the British Museum and in my collection from Windermere, it is certainly not a generic character, and probably represents individual variation. This is borne out by the existence in one vertebra of one of the trout I examined of a similar notched anterior zygapophysis. The structure of the core vertebrae is therefore that of typical vertebrae of either trout or char.

A comparison of the shape of the core scales with that of the trout and char was then made because some scales of the latter have a

square ‚look' not found among trout scales. But as most of the core scales were not whole or, if they were, had the oval shape which characterizes scales from the pelvic region of both trout and char, it was not possible from the shape of the scales to assign the core fish to one or other of the two species.

The scales of a trout are larger than those of a char of the same size, therefore I compared the length of several of the core scales (using the long axis as the unit of measurement) with the lengths of samples of scales taken from the trout of 35.5 to 46.0 cm and char 37.0 to 41.5 cm. The scales from each of these sources showed a wide range in size. Although the core scales were, if anything, nearer in size to the char than to the trout scales, this tendency was not sufficiently well marked to justify accepting the core fish as a char.

The annulus (or check) on a char scale consists of only two or three closely approximated circuli and so is often difficult to locate, whereas on a trout scale it is usually composed of several and is more obvious. The core scales are either torn or if whole are plain, i.e. without circuli in the centre (replacement scales), features which limit the possibility of finding an annulus, but on at least one core scale I found the two or three close circuli that suggest an annulus of the char type. (Plate I d). Although in this and in their general look the core scales are more like those of a char than a trout the evidence is insufficient to justify regarding the core fish as a char rather than the trout. It would be interesting if the core fish were a char because Esthwaite Water holds trout (*Salmo trutta* L.) but no char (*Salvelinus* spp.) nor is there any record of the latter fish being in this lake in historic times.

The vertebrae from Esthwaite Water are, to my knowledge, the first record of fish bones being found in a mud core taken in freshwater and there appears to be only one other record of fish scales from such a core, namely that of LAGLER & VALLENTYNE (1956). They found a scale of a Cyprinodont and of a Cyprinid in a sediment core from Linsley Pond, Connecticut. This sediment was 7,500 years old while that from Esthwaite Water was 10,000 to 12,000 years.

We are much indebted to Dr E. TREWAVES for her help and advice and to Mr. F. J. H. MACKERETH and Mr. E. RAMSBOTTOM for the photographs. The fish remains are deposited with the Freshwater Biological Association and the British Museum (Natural History).

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F. K. Sparrow, Jr. — Aquatic Phycomycetes. Second Revised and Enlarged Edition, 1187 p. + xiii, illustrated, The University of Michigan Press, Ann Arbor (1960). $ 22.50

Important scientific information is usually distributed in three forms: in original publications, in monographs and in textbooks. The first form is the most accurate, but also the most time-consuming for the non-specialist in a particular field. Textbooks give a rapid and easy survey of a broad field, but not infrequently contain basic inaccuracies, which are copied from one author by the other. In the logarithmically growing knowledge of the world around us, each specialty ought to be completely and authoritatively reviewed now and then in the form of a monograph. In this way the laboratory-scientist can refresh his opinions in his domain and — what is probably even more important — get better acquainted with related branches of science.

The monograph of Prof. Sparrow fulfils both requisites admirably. Aquatic phycomycetes constitute a group of molds which are not so easy to work with and on the whole difficult to grow on laboratory media. Very little is thus known on their physiology and biochemistry. The main body of knowledge on these organisms is therefore morphological and taxonomic, which is here thoroughly summarized and discussed. The first edition was published in 1943. The present edition has been brought up to date and includes the diagnoses of 10 orders (*Chrytidiales*, *Blastocladiales*, *Monoblepharidales* *Hypochytriales*, *Plasmodiophorales*, *Saprolegniales*, *Leptomitales*, *Lagenidales*, *Peronosporales* and *Entomophtorales*), 24 families, 152 genera and 781 species. Of each order a description is given of its morphology, development, reproduction, cytology, features of biological interest and genetical data. 929 line illustrations are provided. There are keys to the orders, families, genera and species. After each species description the substrata, collectors, bibliographic citations and country are given. There is an extensive bibliography of over 1200 entries, arranged alphabetically.

This monograph is a standard work. It belongs in the library and on the working bench of mycologists, algologists, botanists, limnologists and bacteriologists of every scientific institute. One can expect that within a few years physiologists, biochemists and enzymologists will attack this group of organisms. Also for them it will become then an indispensable reference book.

Prof. Dr J. De Ley

Lab. for Microbiology
Fac. of Sciences
State Univ.- Gent

Prof. Dr. C. Spehn: Die Tierwelt Mitteleuropas 1. Band, Lief. 3b: „Trematoda und Cestoidea"
Verlag Von Quelle & Meyer, Leipzig 1960, 197 pp.

In this fine book concerning the fauna of Europe Spehn has treated the Trematoda and Cestoidea quite exhaustively.

The author and the series in which his book was published are two guarantees for the excellence of this study.

P.v.O.

F. S. Bodenheimer: „Animal Ecology To-day" Monographiae Biologicae vol. VI. Uitgeverij Dr. W. Junk, Den Haag, 1958. Guilders 28.— 276 pp:

This book is of great importance to all biologists. It is a survey of various chapters of ecology and it is written by the late Professor Bodenheimer who excelled in giving in a concise way the essential facts known on the subjects he treated.

In spite of the fact that the largest part of this book does not speak of hydrobiological subjects, on the whole it is very interesting for hydrobiologists, while the chapters on Marine Bottom Communities and The Habitat Concept of Animal Communities have a direct value for the readers of HYDROBIOLOGIA. I am sure most readers will consult this book with the greatest pleasure.

P.v.O.

F. Wiebach: „Bryozoa". Die Tierwelt Mitteleuropas, 1. Band, Lief. 8. Verlag Von Quelle & Meyer; Leipzig XIX Tafeln, 56 S., DM 7.—

The fauna „Die Tierwelt Mitteleuropas" edited by Brohmer, Ehrmann and Ulmer was interrupted during several years.

Now it has been resumed and various issues appeared these latest years. Here we have a good treatment of the Bryozoa which for many students in this field will be a practical handbook for determining the species of this class.

The introduction gives a short survey of the systematics, the ecology, the biology and the anatomy of the Bryozoa with many biological praticulars.

P.v.O.

Memorie dell'Istituto Italiano di Idrobiologia Dott. Marco de Marchi vol. XI Milano 1959, Ulrico Hoepli. 272 p.

This series is one of the best known hydrobiological publications of its kind and vol. XI (1959) once more brings a collection of quite different as well as important studies on hydrobiological subjects.

Amongst the authors we notice Domenico Povoledo, Livia Tonolli, Franz Ruttner, Maurizio Mirolli, Marian Stangenberg, Maria Giulia Pecorini and Richard Vollenweider.

P.v.O.

S. Stanković „The Balkan Lake Ohrid and its Living World" (Monographiae Biologiae, Vol. IX. Uitgeverij Dr. W. Junk - Den Haag, 1960, 357 p. Guilders 35.—

This is a monography on the lake Ohrid in the Balkan, giving a survey of all what is known about this lake as well as the results of the author's investigations.

It is an excellent summing up and it treats all hydrobiological aspects of the lake: geographical position, physiography, life conditions (thermics, light, water movements, chemistry), the communities (plankton community, benthic communities) the biogeography (the composition of the living world of the lake and its endemism, the lake's origin and history, the biogeographical analysis of the living world of Ohrid) and finally the fishery and the description of the hydrobiological station in Ohrid.

P.v.O.

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